Lexical Functional Grammar

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FUNCTIONAL STRUCTURE

LFG assumes two different ways of representing syntactic structure, the *constituent structure* or *c-structure* and the *functional structure* or *f-structure*. These two structures constitute two subsystems of the overall system of linguistic structures. Functional structure is the abstract functional syntactic organization of the sentence, familiar from traditional grammatical descriptions, representing syntactic predicate-argument structure and functional relations like subject and object. Constituent structure is the overt, more concrete level of linear and hierarchical organization of words into phrases.

Section 1 of this chapter presents motivation for the categories and information appearing in functional structure and outlines some common characteristics of functional structure categories. Section 2 shows that *syntactic subcategorization requirements*, a characterization of the array of syntactic arguments required by a predicate, are best stated in functional terms. The formal representation of functional structure and constraints on f-structure representations are discussed in Section 3. Finally, Section 4 contrasts the LFG view with other theoretical approaches to the definition and treatment of functional structure.

1. FUNCTIONAL INFORMATION AND FUNCTIONAL STRUCTURE

Abstract grammatical relations have been studied for thousands of years. Apollonius Dyscolus, a grammarian in Alexandria in the second century A.D., gave a syntactic description of Greek that characterized the relations of nouns to verbs and other words in the sentence, providing an early characterization of transitivity and "foreshadow[ing] the distinction of subject and object" (Robins 1967). The role of the subject and object and the relation of syntactic predication were fully developed in the Middle Ages by the modistae, or speculative grammarians (Robins 1967; Covington 1984).

More recent work also depends on assuming an underlying abstract regularity operating crosslinguistically. Modern work on grammatical relations and syntactic dependencies was pioneered by Tesnière (1959) and continues in the work of Hudson (1984), Mel'čuk (1988), and others working within the dependency-based tradition. Typological studies are also frequently driven by reference to grammatical relations: for instance, Greenberg (1966) states his word order universals by reference to subject and object. Thus, LFG aligns itself with approaches in traditional, nontransformational grammatical work, in which these abstract relations were assumed.

1.1. Distinctions among Grammatical Functions

It is abundantly clear that there are differences in the behavior of phrases depending on their grammatical function. For example, in languages exhibiting "superiority" effects, there is an asymmetry between subjects and nonsubjects in *multiple wh-questions*, questions with more than one wh-phrase. It is not possible for the object phrase in a wh-question to appear in initial position in the sentence if the subject is also a wh-phrase like *what* or *who* (Chomsky 1981, Chapter 4):

(1) a. *Who saw what?*

b. **What did who see?*

Not all languages exhibit these effects: for example, King (1995, page 56) shows that superiority effects do not hold in Russian. Nevertheless, many languages do exhibit an asymmetry between subjects and nonsubjects in constructions like (1).

In fact, however, the subject-nonsubject distinction is only one aspect of a rich set of distinctions among grammatical functions. Keenan and Comrie (1977) propose a more fine-grained analysis of abstract grammatical structure, the *Keenan-Comrie hierarchy* for relative clause formation. The Keenan-Comrie hierarchy gives a ranking on grammatical functions that constrains relative clause formation by restricting the grammatical function of the argument in the relative clause that is interpreted as coreferent with the modified noun. The border between any two adjacent grammatical functions in the hierarchy can represent a distinction between acceptable and unacceptable relative clauses in a language, and different languages can set the border at different places on the hierarchy:[1]

(2) Keenan-Comrie Hierarchy:

SUBJ > DO > IO > OBL > GEN > OCOMP

Keenan and Comrie state that "the positions on the Accessibility Hierarchy are to be understood as specifying a set of possible grammatical distinctions that a language may make." In some languages, the hierarchy distinguishes subjects from all other grammatical functions: only the subject of a relative clause can be relativized, or interpreted as coreferent with the noun modified by the relative clause. Other languages allow relativization of subjects and objects in contrast to other grammatical functions. This more fine-grained hierarchical structure refines the subject/nonsubject distinction and allows more functional distinctions to emerge.

Keenan and Comrie speculate that their hierarchy can be extended to other processes besides relative clause formation, and indeed Comrie (1975) applies the hierarchy in an analysis of grammatical functions in causative constructions. In fact, the Keenan-Comrie hierarchy closely mirrors the "relational hierarchy" of Relational Grammar, as given by Bell (1983), upon which much work in Relational Grammar is based:

(3) Relational Hierarchy of Relational Grammar:

1 (SUBJ) > 2 (OBJ) > 3 (indirect object)

The Obliqueness Hierarchy of Head-Driven Phrase Structure Grammar (Pollard and Sag 1994) also reflects a hierarchy of grammatical functions like this one. As demonstrated by a large body of work in Relational Grammar, HPSG, LFG, and other theories, the distinctions inherent in these hierarchies are relevant across languages with widely differing constituent structure representations, languages that encode grammatical functions by morphological as well as configurational means. There is a clear and well-defined similarity across languages at this abstract level.

LFG assumes a universally available inventory of grammatical functions:

(4) Lexical Functional Grammar:

SUBJect, OBJect, OBJ_θ, COMP, XCOMP, OBLique$_\theta$, ADJunct, XADJunct

The labels OBJ_θ and OBL_θ represent families of relations indexed by semantic roles, with the θ subscript representing the semantic role associated with the argument. For instance, $\text{OBJ}_{\text{THEME}}$ is the member of the group of thematically restricted OBJ_θ functions that bears the semantic role THEME, and $\text{OBL}_{\text{SOURCE}}$ and OBL_{GOAL} are members of the OBL_θ group of grammatical functions filling the SOURCE and GOAL semantic roles.

[1] The nomenclature that Keenan and Comrie use is slightly different from that used in this book: in their terminology, DO is the direct object, which we call OBJ; IO is the indirect object; OBL is an oblique noun phrase; GEN is a genitive/possessor of an argument; and OCOMP is an object of comparison.

Grammatical functions can be cross-classified in several different ways. The *governable grammatical functions* SUBJ, OBJ, OBJ_θ, COMP, XCOMP, and OBL_θ can be *subcategorized*, or required, by a predicate; these contrast with modifying adjuncts ADJ and XADJ, which are not subcategorizable.

The governable grammatical functions form several natural groups. First, one can distinguish the *core arguments* or *terms* (SUBJ, OBJ, and the family of thematically restricted objects OBJ_θ) from the family of *nonterm* or *oblique* functions OBL_θ. Crosslinguistically, term functions behave differently from nonterms in constructions involving anaphoric binding (Chapter 11) and control (Chapter 12); we will discuss other differences between terms and nonterms in Section 1.3 of this chapter.

Second, SUBJ and the primary object function OBJ are the *semantically unrestricted* functions, while OBL_θ and the secondary object function OBJ_θ are restricted to particular thematic or semantic roles, as the θ in their name indicates. Arguments with no semantic content, like the subject *it* of a sentence like *It rained*, can fill the semantically unrestricted functions, while this is impossible for the semantically restricted functions. We will discuss this distinction in Section 1.4 of this chapter.

Finally, *open* grammatical functions (XCOMP and XADJ), whose subject is controlled by an argument external to the function, are distinguished from *closed* functions. These will be discussed in Section 1.7 of this chapter.

Some linguists have considered inputs and outputs of relation-changing rules like passive to be good tests for grammatical functionhood: for example, an argument is classified as an object in an active sentence if it appears as a subject in the corresponding passive sentence, under the assumption that the passive rule turns an object into a passive subject. However, as we will discuss in Chapter 8, grammatical function alternations like passive are best viewed not in terms of transformational rules, or even in terms of lexical rules manipulating grammatical function assignment, but as alternative means of linking grammatical functions to semantic arguments. Therefore, appeal to these processes as viable diagnostics of grammatical functions requires a thorough understanding of the theory of argument linking, and these diagnostics must be used with care.

In the following, we present the inventory of grammatical functions assumed in LFG theory and discuss a variety of grammatical phenomena that make reference to these functions. Some of these phenomena are sensitive to a grammatical hierarchy, while others can refer either to specific grammatical functions or to the members of a larger class of functions. Thus, the same test (for example, relativizability) might distinguish subjects from all other grammatical functions in one language, but might pick out both subjects and objects in another language. A number of tests are also specific to particular languages or to particular types of languages: for example, switch-reference constructions, constructions in which a verb is inflected according to whether its subject is coreferential with the subject of another verb, do not constitute a test for subjecthood in a language in which switch-reference plays no grammatical role. In a theory like LFG, grammatical functions are theoretical primitives, not defined in phrasal or semantic terms; therefore, we do not define grammatical functions in terms of a particular, invariant set of syntactic behaviors. Instead, grammatical phenomena can be seen to cluster and distribute according to the grammatical organization provided by functional roles.

1.2. Governable Grammatical Functions and Modifiers

A major division in grammatical functions distinguishes arguments of a predicate from modifiers. The arguments are the *governable grammatical functions* of LFG; they are subcategorized for, or *governed*, by the predicate. Modifiers modify the phrase with which they appear, but they are not governed by the predicate.

(5) Governable grammatical functions:

$$\underbrace{\text{SUBJ OBJ XCOMP COMP OBJ}_\theta\ \text{OBL}_\theta}_{\text{GOVERNABLE GRAMMATICAL FUNCTIONS}} \qquad \underbrace{\text{ADJ XADJ}}_{\text{MODIFIERS}}$$

Linguists have proposed a number of identifying criteria for governable grammatical functions. Dowty (1982) proposes two tests to distinguish between governable grammatical functions and modifiers: what he calls the *entailment test*, namely that using a predicate entails the existence of all of its arguments, but not its modifiers; and what he calls the *subcategorization test*, namely that it is possible to omit modifiers but not arguments when a predicate is used. These tests do capture some intuitively correct properties of the distinction between governable grammatical functions and modifiers; however, neither test is completely successful in distinguishing between them.

Dowty's first test, the entailment test, fails for some phrases that seem uncontroversially to be modifiers. In particular, since the use of many predicates entails that some event occurred at some place at some time, the test implies that temporal modifiers are arguments of those predicates. For instance, the use of the verb *yawned* in a sentence like *David yawned* entails that there was some past time at which David yawned; however, few linguists would conclude on this basis that *previously* is an argument of *yawned* in a sentence like *David yawned previously*. Additionally, as pointed out by Anette Frank (p.c.), the entailment test incorrectly predicts that the object argument of an intensional verb such as *deny* or *seek* is not a governable grammatical function, since a sentence like *David is seeking a solution to the problem* does not imply that a solution exists. Further, syntactically required but semantically empty phrases that are governed by a predicate are not classified as syntactic arguments by this test; the existence of some entity denoted by the subject of *rained* is not entailed by the sentence *It rained*.

Dowty's second test is also problematic. It clearly fails in "pro-drop" languages — languages where some or all arguments of a predicate can be omitted — but even in English the test does not work well. The test implies that because a sentence like *David ate* is possible, the object *lunch* in *David ate lunch* is not an argument but a modifier.

Even though Dowty's tests do not succeed in correctly differentiating arguments and modifiers, certain valid implications can be drawn from his claims. If a phrase is an argument, it is either obligatorily present or it is entailed by the predicate. If a phrase is a modifier, it can be omitted. Stronger conclusions do not seem to be warranted, however.

A number of other tests have been shown to illuminate the distinction between arguments and modifiers:

MULTIPLE OCCURRENCE: Modifiers can be multiply specified, but arguments cannot, as noted by Kaplan and Bresnan (1982):

(6) a. *The girl handed the baby a toy on Tuesday in the morning*.
b. **David saw Tony George Sally*.

ANAPHORIC BINDING PATTERNS: In some languages, binding patterns are sensitive to the syntactic argument structure of predicates and therefore to the argument/modifier distinction. For example, the Norwegian reflexive pronoun *seg selv* requires as its antecedent a coargument of the same predicate. Since a modifier is not an argument of the main predicate, the reflexive *seg selv* may not appear in a modifier phrase if its antecedent is an argument of the main verb (Hellan 1988; Dalrymple 1993). The subscript *i* in the glosses of the following examples indicates coreference between an anaphor and its intended antecedent:

(7) *Jon forakter seg selv.*
Jon despises self
'Jon$_i$ despises himself$_i$.'

(8) *Jon fortalte meg om seg selv.*
Jon told me about self
'Jon$_i$ told me about himself$_i$.'

(9) **Hun kastet meg fra seg selv.*
She threw me from self
'She$_i$ threw me away from herself$_i$.'

ORDER DEPENDENCE: The contribution of modifiers to semantic content can depend upon their relative order, as noted by Pollard and Sag (1987, section 5.6). The meaning of a sentence may change if its modifiers are reordered:

(10) a. *Kim jogged for twenty minutes twice a day*.
b. *Kim jogged twice a day for twenty years*.

(11) a. *Kim jogged reluctantly twice a day*.
b. *Kim jogged twice a day reluctantly*.

In contrast, reordering arguments may affect the rhetorical structure of the sentence, focusing attention on one or another argument, but does not alter the conditions under which the sentence is true.

EXTRACTION PATTERNS: A long-distance dependency cannot relate a wh-phrase that appears in sentence-initial position to a position inside some modifiers, as noted by Pollard and Sag (1987, section 5.6) (see also Huang 1982; Rizzi 1990):

(12) a. **Which famous professor did Kim climb K2 without oxygen in order to impress ___?*
b. *Which famous professor did Kim attempt to impress ___ by climbing K2 without oxygen?*

This generalization is not as robust as those discussed above, since as Pollard and Sag point out, it is possible to extract a phrase from some modifiers:

(13) *Which room does Julius teach his class in ___?*

1.3. Terms and Nonterms

The governable grammatical functions can be divided into *terms* or direct functions, and *nonterms* or obliques. The subject and object functions are grouped together as terms:[2]

(14) Terms and nonterms:

$$\underbrace{\text{SUBJ OBJ OBJ}_\theta}_{\text{TERMS}} \quad \underbrace{\text{OBL}_\theta \text{ XCOMP COMP}}_{\text{NONTERMS}}$$

A number of tests for termhood in different languages have been proposed:

[2]Relational grammar (Perlmutter and Postal 1983a) also recognizes this basic division of grammatical functions into "term relations" and "oblique relations." Terms are also sometimes referred to as "core functions" (Andrews 1985; Bresnan 2001b).

AGREEMENT: In some languages, termhood is correlated with verb agreement; in fact, this observation is encoded in Relational Grammar as the Agreement Law (Frantz 1981): "Only nominals bearing term relations (in some stratum) may trigger verb agreement." Alsina (1993), citing Rosen (1990) and Rhodes (1990), notes that all terms, and only terms, trigger verb agreement in Ojibwa and Southern Tiwa.

ANAPHORIC BINDING PATTERNS: In some languages, terms behave differently from obliques with respect to anaphoric binding. Sells (1988) shows that in Albanian, a term can antecede a term or oblique reflexive, while an oblique only antecedes another oblique. Among the term arguments, possible binding relations are constrained by a thematic hierarchy. Hellan (1988), Dalrymple and Zaenen (1991), and Dalrymple (1993) discuss Norwegian data that point to a similar conclusion.

CONTROL: Kroeger (1993) shows that in Tagalog, only a term can be the controllee in the participial complement construction, and only a term can be a controller in the participial adjunct construction.

Alsina (1993) provides an extensive discussion of termhood in a number of typologically very different languages, and Andrews (1985) further discusses the term/nonterm distinction.

Often, discussion of terms focuses exclusively on the status of nominal arguments of a predicate and does not bear on the status of verbal or sentential arguments. The infinitive phrase *to be yawning* in example (15) bears the open grammatical function XCOMP:

(15) *Chris seems to be yawning*.

The sentential complement *that Chris was yawning* bears the grammatical function COMP in (16):

(16) *David thought that Chris was yawning*.

The XCOMP function differs from the COMP function in not containing an overt SUBJ internal to its phrase; XCOMP is an open function, whose SUBJ is determined by means of lexical specifications on the predicate that governs it, as discussed in Section 1.7 of this chapter. What is the termhood status of the XCOMP and COMP arguments?

Zaenen and Engdahl (1994) classify XCOMP as a kind of oblique in their analysis of the linking of sentential and predicative complements, though without providing specific evidence in support of this classification. Oblique arguments are nonterms, and so if Zaenen and Engdahl are correct, XCOMP would be classified as a nonterm.

Word order requirements on infinitival and finite complements in English provide some support for this position. Sag (1986) claims that in English, term phrases always precede obliques:

(17) a. *David gave a book to Chris.*

b. **David gave to Chris a book.*

Infinitival and sentential complements bearing the grammatical functions XCOMP and COMP obey different word order restrictions from term noun phrases. The following data indicate that XCOMPs are obliques:

(18) a. *Kim appeared to Sandy to be unhappy.*

b. *Kim appeared to be unhappy to Sandy.*

Since the XCOMP *to be unhappy* is not required to precede the oblique phrase *to Sandy* but can appear either before or after it, Sag's diagnostic indicates that the XCOMP must also be an oblique. Similar data indicate that the COMP is also an oblique phrase:

(19) a. *David complained that it was going to rain to Chris.*

b. *David complained to Chris that it was going to rain.*

We will return to a discussion of COMP and XCOMP in Section 1.7 of this chapter.

1.4. Semantically Restricted and Unrestricted Functions

The governable grammatical functions can be divided into *semantically restricted* and *semantically unrestricted* functions (Bresnan 1982a):

(20) Semantically unrestricted and restricted functions:

$$\underbrace{\text{SUBJ OBJ}}_{\text{SEMANTICALLY UNRESTRICTED}} \qquad \underbrace{\text{OBJ}_\theta \ \text{OBL}_\theta}_{\text{SEMANTICALLY RESTRICTED}}$$

Semantically unrestricted functions like SUBJ and OBJ can be associated with any semantic role, as Fillmore (1968) shows:

(21) a. *He hit the ball.*

b. *He received a blow.*

c. *He received a gift.*

d. *He loves her.*

e. *He has black hair.*

The examples in (21) show that the SUBJ of different verbs can be associated with different semantic roles: AGENT in a sentence like *He hit the ball*, GOAL in a sentence like *He received a blow*, and so on. Similar examples can be constructed for OBJ.

In contrast, members of the semantically restricted family of functions OBJ_θ and OBL_θ are associated with a particular semantic role. For example, the $\text{OBJ}_{\text{THEME}}$ function is associated only with the semantic role of THEME, and the OBL_{GOAL} is associated with GOAL. Languages may differ in the inventory of semantically restricted functions they allow. For example, English allows only $\text{OBJ}_{\text{THEME}}$:

(22) a. *I gave her a book.*

b. *I made her a cake.*

c. *I asked him a question.*

Other semantic roles cannot be associated with the second object position:

(23) a. **I made a cake the teacher.*

b. **I asked a question David.*

Section 1.6 of this chapter provides a more complete discussion of the double object construction and verb alternations; see also Levin (1993).

The division between semantically restricted and semantically unrestricted arguments predicts what in Relational Grammar is called the Nuclear Dummy Law (Frantz 1981; Perlmutter and Postal 1983a): only semantically unrestricted functions can be filled with semantically empty arguments like the subject *it* of *It rained*. This is because the semantically restricted functions are associated only with a particular semantic role; since a semantically empty argument is incompatible with these semantic requirements, it cannot appear in these positions.

The functions XCOMP and COMP seldom figure in discussions of semantically restricted and unrestricted arguments, and it is not completely clear how they should be classified. There does seem to be some pretheoretic evidence for classifying COMP as semantically *unrestricted*, since different semantic entailments can attach to different uses of XCOMP and COMP. If these different semantic entailments are taken to delineate distinctions among different members of a set of semantic roles, then this would mean that XCOMP and COMP should be classified as semantically unrestricted.

In a pioneering paper, Kiparsky and Kiparsky (1970) note that sentential arguments bearing the COMP function may be *factive* or *nonfactive* with respect to their complements: for factive complements, "the embedded clause expresses a true proposition, and makes some assertion about that proposition," whereas such a presupposition is not associated with nonfactive complements. Kiparsky and Kiparsky also distinguish *emotive* from *nonemotive* sentential arguments; emotive complements are those to which a speaker expresses a "subjective, emotional, or evaluative reaction":

(24) a. Factive emotive: *I am pleased that David came.*

b. Factive nonemotive: *I forgot that David came.*

c. Nonfactive emotive: *I intend that David come.*

d. Nonfactive nonemotive: *I suppose that David came.*

It is not clear, however, whether the semantic differences explored by Kiparsky and Kiparsky should be taken to indicate that these arguments, which all bear the grammatical function COMP in English, bear different semantic roles. We leave this question for future research.

We have explored several natural classes of grammatical functions: governable grammatical functions and modifiers, terms and nonterms, semantically restricted and unrestricted functions. We now turn to an examination of particular grammatical functions, beginning with the subject function.

1.5. SUBJ

The subject is the term argument that ranks the highest on the Keenan-Comrie relativization hierarchy. As discussed in Section 1.1 of this chapter, their hierarchy is applicable to other processes besides relativization: if only a single type of argument can participate in certain processes for which a functional hierarchy is relevant, that argument is often the subject.

There is no lack of tests referring specifically to the subject function:

AGREEMENT: The subject is often the argument that agrees with the verb in languages in which verbs bear agreement morphology; indeed, Moravcsik (1978) proposes the following language universal:

> There is no language which includes sentences where the verb agrees with a constituent distinct from the intransitive subject and which would not also include sentences where the verb agrees with the intransitive subject. (Moravcsik 1978, page 364)

English is a language that exhibits subject-verb agreement; the fullest paradigm is found in the verb *to be*:

(25) *I am* / *You are* / *He is*

HONORIFICATION: Matsumoto (1996) calls this the most reliable subject test in Japanese. Certain honorific forms of verbs are used to honor the referent of the subject:

(26) *sensei wa hon o o-yomi ni narimashi-ta*
teacher TOPIC book ACC HONORIFIC-read COPULA become.POLITE-PAST
'The teacher read a book.'

The verb form *o-V ni naru* is used to honor the subject *sensei* 'teacher'. It cannot be used to honor a nonsubject, even if the argument is a "logical subject"/AGENT:

(27) **Jon wa sensei ni o-tasuke-rare ni nat-ta*
John TOPIC teacher by HONORIFIC-help-PASSIVE COPULA become-PAST
'John was saved by the teacher.'

SUBJECT NONCOREFERENCE: Mohanan (1994) shows that the antecedent of a pronoun in Hindi cannot be a subject in the same clause, although a nonsubject antecedent is possible:

(28) *Vijay ne Ravii ko uskii saikil par biṭhaayaa*
Vijay ERG Ravi ACC his bicycle LOC sit.CAUSATIVE.PERFECT
'Vijay$_i$ seated Ravi$_j$ on his$_{*i,j}$ bike.

LAUNCHING FLOATED QUANTIFIERS: Kroeger (1993, page 22) shows that the subject launches *floating quantifiers*, quantifiers that appear outside the phrase they quantify over, in Tagalog.[3]

(29) *sinusulat lahat ng-mga-bata ang-mga-liham*
IMPERFECT.write.OBJECTIVE all GEN-PL-child NOM-PL-letter
'All the letters are written by the/some children.'
(Does not mean: 'All the children are writing letters.')

Bell (1983, pages 154 ff.) shows that the same is true in Cebuano.

This is only a sampling of the various tests for subjecthood. Many other tests could, of course, be cited (see, for example, Li 1976; Zaenen 1982; Zaenen et al. 1985).

The question of whether all verbal predicates in every language must contain a subject is a vexed one. The Subject Condition[4] was discussed by Bresnan and

[3] Kroeger attributes example (29) to Schachter (1976).

[4] The Subject Condition is called the *Final 1 Law* in Relational Grammar (Frantz 1981; Perlmutter and Postal 1983a) and the *Extended Projection Principle* in Government and Binding Theory (Chomsky 1981).

Kanerva (1989), who attribute it originally to Baker (1983) (see also Andrews 1985; Levin 1987; Butt et al. 1999):

(30) Subject Condition:

Every verbal predicate must have a SUBJ.

Though the Subject Condition seems to hold in English, and perhaps in many other languages as well, there are languages in which the requirement does not so clearly hold. For example, German impersonal passives, as in (31), are traditionally analyzed as subjectless clauses:

(31) ... *weil getanzt wurde*
because danced was
'because there was dancing'

However, Berman (1999) claims that clauses like (31) contain an unpronounced expletive subject, and thus that the Subject Condition is not violated.

Other cases of apparently subjectless clauses are also found. Simpson (1991, page 29) notes that subjects of participial modifiers in Russian are required to corefer with the matrix subject:

(32) *bystro temneja, tuča pokryla vse nebo.*
quickly darken.PARTICIPLE cloud.FEM.NOM cover.PAST.FEM all sky
'As it quickly darkened, the cloud covered the whole sky.'

However, some weather verbs in Russian appear to be subjectless and cannot appear with participles which require subject control:

(33) **temneja, stalo očen' xolodno.*
darken.PARTICIPLE become.PAST.NEUT very cold.NEUT
'When getting dark, it became very cold.'

If Russian obeyed the Subject Condition, example (33) would be expected to be grammatical. It may be, then, that the Subject Condition is a language-particular requirement imposed by some but not all languages, rather than a universal requirement.

1.6. The Object Functions

Grammatical phenomena in which a grammatical function hierarchy is operative may sometimes group subject and object arguments together in distinction to other arguments, and in fact a number of grammatical processes refer to the subject and object functions in distinction to other grammatical functions. Other phenomena are describable specifically in terms of the object function; for purposes of our current discussion, these object tests are more interesting. Some of these are:

AGREEMENT: As noted in Section 1.3 of this chapter, terms are often registered by agreement morphemes on the verb. Often, the object is uniquely identified by agreement: some languages have object agreement. For example, Georgopoulos (1985) describes OBJ agreement in Palauan:

(34) *ak-uldenges-terir a resensei er ngak*
1SG.PERFECT-honor-3PL teachers PREP me
'I respected my teachers.'

In (34), the morpheme *-terir* shows third person plural agreement with the OBJ *a resensei* 'teachers'.

CASEMARKING: In some limited circumstances, objects can be distinguished by casemarking, though this test must be used with care: in general, there is no one-to-one relation between the morphological case that an argument bears and its grammatical function, as we will see in Section 4.1 of this chapter. Mohanan (1982) discusses casemarking in Malayalam, showing that ACCusatively marked noun phrases are unambiguously objects (see also Mohanan 1994, pages 89–90) :

(35) *kuṭṭi aanaye nuḷḷi*
child elephant.ACC pinched
'The child pinched the elephant.'

However, Mohanan goes on to show that many phrases in Malayalam that are OBJ are not marked with ACC case. That is, every phrase in Malayalam that is ACC is an OBJ, but not all OBJs are ACC.

RELATIVIZATION: Givón (1997, section 4.4.3) notes that only subjects and objects can be relativized in Kinyarwanda, and only objects can be relativized with a gap; relativization of subjects requires the use of a resumptive pronoun.

Further discussion of object tests is provided by Baker (1983) for Italian and Dahlstrom (1986b) for Cree. Andrews (1985) also gives a detailed discussion of object tests in various languages.

1.6.1. MULTIPLE OBJECTS

Many languages have more than one phrase bearing an object function. English is one such language:

(36) *He gave her a book.*

Zaenen et al. (1985) discuss Icelandic, another language with multiple object functions, and note the existence of asymmetries between the two kinds of objects. For instance, the primary object can be the antecedent of a reflexive contained in the secondary object:

(37) *Ég gaf ambáttina [konungi sínum].*
I gave slave.DEF.ACC king.DAT self's
'I gave the slave$_i$ (OBJ) to self's$_i$ king (OBJ2).'

However, the secondary object cannot antecede a reflexive contained in the primary object:

(38) **Sjórinn svipti manninum [gömlu konuna sína].*
sea.DEF deprived man.DEF.DAT old wife.DEF.ACC self's
'The sea deprived of the man$_i$ (OBJ2) self's$_i$ old wife (OBJ).'

Dryer (1987) also presents an extensive discussion of the behavior of objects in languages with multiple OBJ functions and of their groupings with respect to semantic roles.

Earlier work in LFG concentrated on languages like English and Icelandic, which each have two object functions. In such languages, the primary object was called the OBJ, and the secondary object was called the OBJ2, as in examples (37–38). Further research has expanded our knowledge of the properties of objects, and in later work, it became evident that this simple classification was neither sufficient nor explanatory.

In fact, languages allow a single *thematically unrestricted* object, the primary OBJ. In addition, languages may allow one or more secondary, *thematically restricted* objects. That is, the argument that was originally identified as OBJ2 in English is only one member of a family of semantically restricted functions, referred to collectively as OBJ$_\theta$ (Bresnan and Kanerva 1989). This classification more clearly reflects the status of secondary objects as restricted to particular semantic roles, and also encompasses analyses of languages whose functional inventory includes more than two object functions.

In English, as discussed in Section 1.4 of this chapter, the thematically restricted object must be a theme; other semantic roles, such as goal or beneficiary, are not allowed:

(39) a. *I made her a cake.*

b. **I made a cake her.*

In contrast, as Bresnan and Moshi (1990) show, languages like Chaga allow multiple thematically restricted objects with roles other than THEME:[5]

[5] Numbers in the glosses indicate the noun class of the arguments.

(40) *n-ä́-lꜝé-kú-shí-kí-kóṛ-í-à*
FOCUS-1SUBJ-PAST-17OBJ-8OBJ-7OBJ-cook-APPLICATIVE-FV
'She/he cooked it with them there.'

This example contains three object markers, representing a locative object, an instrumental object, and a patient object. According to Bresnan and Moshi's analysis, in this example the instrumental OBJ is the unrestricted OBJ; the locative and patient arguments bear thematically restricted OBJ functions OBJ$_{\mathrm{LOC}}$ and OBJ$_{\mathrm{PATIENT}}$. Bresnan and Moshi provide much more discussion of OBJ$_\theta$ in Chaga and other Bantu languages.

1.6.2. 'Direct' and 'Indirect' Object

In traditional grammatical descriptions, the grammatical function borne by *her* in the English example in (41) has sometimes been called the "indirect object," and *the book* has been called the "direct object":

(41) *He gave her a book.*

The phrase *the book* is also traditionally assumed to be a direct object in examples like (42):

(42) *He gave a book to her.*

The classification of *the book* as a direct object in both (41) and (42) may have a semantic rather than a syntactic basis: there may be a tendency to assume that *the book* must bear the same grammatical function in each instance because its semantic role does not change. As we have seen, the LFG view differs: in example (41), the phrase *her* bears the OBJ function, while in example (42), the phrase *a book* is the OBJ.

Within the transformational tradition, evidence for the LFG classification for English came from certain formulations of the rule of passivization, which applies uniformly to "transform" an object into a subject:

(43) a. *He gave her a book.*
She was given a book.

b. *He gave a book to her.*
A book was given to her.

If the "passive transformation" is stated in terms of the indirect object/object distinction, or its equivalent in phrase structure terms, the generalization is complicated to state: the direct object becomes the passive subject only if there is no indirect object present; otherwise, the indirect object becomes the subject. On the other hand, the transformation is easy to state if the first noun phrase following the verb is classified as the object and the second bears some other function.

In LFG, however, the theory of grammatical function alternations is formulated in terms of a characterization of possible mappings between semantic roles and grammatical functions, as described in Chapter 8, and is not transformational in nature. Thus, we must look to other grammatical phenomena for evidence bearing on the classification of object functions.

Dryer (1987) presents several arguments that in English, an opposition between primary/unrestricted objects (OBJ) and secondary/restricted objects (OBJ$_\theta$), as proposed in LFG, allows a more satisfactory explanation of the facts than the direct/indirect object distinction. Dryer primarily discusses evidence from prepositional casemarking and word order. For example, given a distinction between primary and secondary objects, we can succinctly describe word order within the English VP: the primary object immediately follows the verb, with the secondary object following it.[6]

In other languages, the situation is even clearer. Alsina (1993) examines the object functions in Chicheŵa and their role in the *applicative* construction. In this construction, an affix is added to the verb that signals a requirement for an additional syntactic argument besides the arguments ordinarily required by the verb; we focus here on the *benefactive applicative* construction, in which the applicative affix signals that an OBJ argument bearing a beneficiary thematic role is required. Alsina (1993) shows that the syntactic OBJ properties of the patient argument in the nonapplied form are displayed by the beneficiary argument in the applied form. The primary/nonrestricted OBJ is the argument that immediately follows the verb; this argument is the patient in the nonapplied form, and the beneficiary in the applied form of the verb:

(44) a. *nkhandwe zi-ku-mény-á njōvu*
10.foxes 10SUBJ-PRES-hit-FV 9.elephant
'The foxes are hitting the elephant.'

b. *nkhandwe zi-ku-mény-ér-a aná njōvu*
10.foxes 10SUBJ-PRES-hit-APPLICATIVE-FV 2.children 9.elephant
'The foxes are hitting the elephant for the children.'

The patient argument alternates with the OBJ marker in the nonapplied form, and the beneficiary argument alternates with the OBJ marker in the applied form:

(45) a. *nkhandwe zi-ku-í-mẽ́ny-a*
10.foxes 10SUBJ-PRES-9OBJ-hit-FV
'The foxes are hitting it.'

[6]Dryer assumes a more complicated crosslinguistic typology of object functions than is generally accepted in LFG. His richer typology turns out to be best explained in terms of different strategies for relating semantic roles to object grammatical functions, as described in Chapter 8.

b. *nkhandwe zi-ku-wá-mény-er-á njōvu*
10.foxes 10SUBJ-PRES-9OBJ-hit-APPLICATIVE-FV 9.elephant
'The foxes are hitting the elephant for them.'

This and other evidence is best explained by assuming that the patient arguments in (44a) and (45a) and the beneficiary arguments in (44b) and (45b) bear the nonrestricted/primary OBJ function, while the patient arguments in (44b) and (45b) bear the restricted/secondary OBJ$_\theta$ function and behave differently. In other words, the syntactic behavior of the arguments in examples (44) and (45) is best explained by reference to a distinction between OBJ and OBJ$_\theta$, not between direct and indirect objects.

1.7. COMP, XCOMP, and XADJ

The COMP, XCOMP, and XADJ functions are clausal functions, differing in whether or not they contain a overt SUBJ noun phrase internal to their phrase. The COMP function is a *closed* function containing an internal SUBJ phrase. The XCOMP and XADJ functions are *open* functions that do not contain an internal subject phrase; their SUBJ must be specified externally to their phrase.[7]

(46) Open and closed functions:

$$\underbrace{\text{SUBJ OBJ COMP OBJ}_\theta\ \text{OBL}_\theta\ \text{ADJ}}_{\text{CLOSED}}\quad \underbrace{\text{XCOMP XADJ}}_{\text{OPEN}}$$

The COMP function is the function of sentential complements, familiar from traditional grammatical description. A COMP can be declarative, interrogative, or exclamatory (Culy 1994):

(47) a. *David complained that Chris yawned.*

b. *David wondered who yawned.*

c. *David couldn't believe how big the house was.*

The XCOMP function is an open complement function, the one borne by a phrase like *to yawn* in the examples in (48). In those examples, the SUBJ of the XCOMP is also an argument of the matrix verb, *David* in both of the examples in (48):

(48) a. *David seemed to yawn.*

b. *Chris expected David to yawn.*

[7]Arka and Simpson (1998) propose that some control constructions in Balinese involve an open SUBJ function: for instance, in the Balinese equivalent of *I tried to take the medicine*, the infinitive phrase *to take the medicine* can bear the SUBJ function, with its SUBJ controlled by the term argument *I*. We do not explore this possibility further here.

Like XCOMP, the XADJ function is an open function, whose SUBJ must be specified externally; unlike XCOMP, XADJ is a modifier, not a governable grammatical function. In example (49), the SUBJ of the XADJ *stretching his arms* is also the SUBJ of the matrix clause, *David*:

(49) *Stretching his arms, David yawned.*

We will return to a discussion of XCOMP, XADJ, and control in Chapter 12.

There has not been universal agreement as to the status of the grammatical function COMP. Alsina (1993) claims that the COMP function is actually superfluous and that sentential complements are best analyzed as bearing the function OBJ. On this view, any difference between nominal objects and sentential complements follows solely from their difference in phrase structure category, since at the functional level they both bear the OBJ function.

In fact, however, several arguments can be made against discarding the grammatical function COMP altogether: there are phenomena that can only be explained by assuming the existence of the grammatical function COMP as distinct from OBJ. First, if all sentential complements are OBJ and not COMP, they would be classified as terms. In this case, the evidence presented in Section 1.3 of this chapter, indicating that English has sentential complements that are not terms, would remain unexplained. Second, if English sentential complements are analyzed as objects, then we must assume that English admits sentences with three OBJ functions, but only when one of the OBJ functions is sentential rather than nominal:

(50) *David bet [Chris] [five dollars] [that she would win].*

Most importantly, there is evidence for a split in the syntactic behavior of sentential complements in a number of languages; as discussed by Dalrymple and Lødrup (2000), this evidence is best explained by analyzing some sentential complements in these languages as OBJ, and some as COMP. In Swedish, clausal complements bearing the OBJ function can be pronominalized and can topicalize, as shown in examples (51a–c):[8]

(51) a. *Man antar att sosserna vinner valet.*
One assumes that social.democrats.DEF win election.DEF
'One assumes that the Social Democrats will win the election.'

b. *Man antar det.*
One assumes that
'One assumes that.'

c. *Att sosserna vinner valet antar man.*
That social.democrats.DEF win election.DEF assumes one
'That the Social Democrats will win the election, one assumes.'

[8]Examples (51a–c) are due to Engdahl (1999).

In contrast, Swedish complement clauses bearing the COMP function do not display these properties:

(52) a. *Kassören yrkade att avgiften skulle höjas.*
cashier.DEF insisted that tax.DEF should be.increased
'The cashier insisted that the tax should be increased.'

b. **Kassören yrkade det.*
cashier.DEF insisted that
'The cashier insisted it.'

c. **Att avgiften skulle höjas yrkade kassören.*
That tax.DEF should be.increased insisted cashier.DEF
'That the tax should be increased, the cashier insisted.'

As Dalrymple and Lødrup (2000) show, other languages also show a similar split in behavioral properties of sentential complements, with some sentential complements patterning with nominal OBJ arguments and others exhibiting behavior typical of COMP arguments. Thus, the COMP grammatical function cannot be eliminated from grammatical description, since many sentential complements must be analyzed as bearing the COMP function.

1.8. Oblique Arguments: OBLique$_\theta$

Oblique arguments are those that are associated with particular semantic roles and marked to indicate their function overtly. In languages like English, oblique arguments are prepositional phrases, while in other languages, as discussed by Nordlinger (1998), oblique arguments are casemarked rather than appearing as prepositional or postpositional phrases.

LFG assumes that there are two types of oblique arguments (Bresnan 1982a). Arguments of the first type are marked according to the semantic role of the argument, such as the goal *to*-phrase of a verb such as *give*. This class corresponds to the category of *semantic case* in the casemarking classification scheme of Butt and King (1999a), since semantic case is governed by generalizations about the relation between case and semantic role.

Arguments of the second type are marked idiosyncratically, and the form of the casemarking is lexically specified by the governing predicate. This class corresponds to the category of *quirky case* in Butt and King's classification scheme.[9]

1.8.1. Semantically Marked Obliques

The phrase *to Chris* in example (53) bears the OBL$_{\text{GOAL}}$ grammatical function:

[9]As Butt and King (1999a) point out, semantic and quirky case can appear on terms as well as obliques. Butt and King also discuss *structural case* and *default case*, which appear on terms.

(53) *David gave the book to Chris.*

The semantic role of the OBL_{GOAL} argument is marked by the preposition *to*. It is not possible for more than one oblique argument to have the same semantic role:

(54) **David gave the book to Chris to Ken.*

In languages like Warlpiri, an OBL_{LOC} phrase such as *kirri-ngka* 'large camp' is marked with locative casemarking rather than a preposition or postposition (Simpson 1991; Nordlinger 1998):

(55) *kirri-ngka* *wiri-ngka-rlipa* *nyina-ja*
large.camp-LOC big-LOC-1PL.INCLUSIVE.SUBJ sit-PAST
'We sat in the large camp.'

Locative casemarking plays a similar role to the preposition in example (54), to mark the semantic role of the argument.

1.8.2. Idiosyncratic Prepositional Marking

An oblique phrase may also be required to bear a particular form unrelated to the semantic role of the argument. For such cases, Bresnan (1982a) suggests the presence of a FORM feature that is specified by the predicate, as in (56):

(56) *Chris relied on/*to/*about David.*

In this case, the form of the preposition *on* in the phrase *on David* is stipulated by the predicate *relied*. Butt et al. (1999) provide more discussion of oblique phrases with idiosyncratic prepositional marking.

1.9. Other Functional Attributes

The table on page 28 gives a list of some of the more commonly assumed f-structural features together with the values of these features (see also Butt et al. 1999). The appearance and distribution of these f-structural features is defined in terms of functional syntactic information, and so their presence at f-structure is crucial: CASE and agreement features are associated with particular grammatical functions; features specifying form, such as VFORM, are relevant at a functional syntactic level for specifying the required morphological form of an argument; and "sequence of tense" phenomena govern syntactic requirements on tense and aspect realization. Only features that can be argued to play a role in functional syntactic constraints are represented at f-structure; Chapter 7 discusses the non-syntactic structures of LFG, the features they contain, and their relation to functional structure.

	Feature	Value
Person:	PERS	Set of atomic values (see Chapter 13)
Gender:	GEND	Set of atomic values (see Chapter 13)
Number:	NUM	SG, DUAL, PL,...
Case:	CASE	Set of case values NOM, ACC,...(see Chapter 13)
Prepositional "case":	PCASE	The family of grammatical functions OBL_θ
Surface form:	FORM	Surface word form
Verb form:	VFORM	PASTPART, PRESPART,...
Complementizer form:	COMPFORM	Surface form of complementizer: THAT, WHETHER,...
Tense:	TENSE	PRES, PAST,...
Aspect:	ASPECT	F-structure representing complex description of sentential aspect. Sometimes abbreviated as e.g. PRES.IMPERFECT
Pronoun type:	PRONTYPE	REL, WH,...

2. SUBCATEGORIZATION

At a minimum, the information that must be lexically associated with a word is its meaning. Research has shown that the syntactic behavior of a word can be partially predicted from this information; this is because a number of regularities govern the relation between the meaning of a predicate and the grammatical functions of its arguments, as we will discuss in detail in Chapter 8. LFG and other linguistic theories define and capitalize on this relation in their theory of syntactic subcategorization.

LFG assumes that syntactic subcategorization requirements of predicates are stated at the f-structure level, in functional rather than phrasal terms. Predicates require a set of arguments bearing particular semantic roles. These roles are associated with grammatical functions according to a theory of argument mapping, to be discussed in Chapter 8. In turn, these grammatical functions are realized at the level of constituent structure in a variety of ways, as required by particular languages: in some languages, grammatical functions are associated with particular phrase structure positions, while in other languages, grammatical functions may be signaled by particular kinds of morphological marking on the head or on the argument (see Chapter 5, Section 4).

In contrast to this view, and in line with proposals in transformational grammar (Chomsky 1965), some linguistic theories state subcategorization requirements in phrase structure terms rather than in terms of abstract functional syntactic organization. There are many reasons to question the viability of this position, since the bulk of phrase structure information is never relevant to the satisfaction of subcategorization requirements. As Grimshaw (1982) points out, predicates never vary idiosyncratically in terms of which phrasal position they require their arguments to be in; for example, there are no exceptional verbs in English which require their objects to appear preverbally rather than postverbally. Subcategorization according to constituent structure configuration rather than functional structure leads to the incorrect expectation that such exceptional verbs should exist. In fact, however, we can cleanly state subcategorization requirements in terms of abstract functional structure; the claim that all phrasal and configurational information is always relevant to subcategorization is too strong.

There is evidence that one particular type of constituent structure information may in some cases be relevant to subcategorization requirements: cases in which a predicate idiosyncratically requires an argument of a particular phrasal category. Other kinds of phrasal information, such as position, never play a role in subcategorization requirements. However, one must take care in identifying situations in which such requirements seem to hold. Often, as Maling (1983) demonstrates, apparent evidence for subcategorization for a particular phrase structure category turns out on closer examination to be better analyzed as a requirement for an argument of a particular semantic type, together with a strong correlation between that type and a particular phrasal category most often used to express it. Maling notes that predicates like *seem* have often been claimed to require adjective phrase complements and to disallow prepositional phrase complements:

(57) a. *Sandy seems clever.*

b. **Sandy seems out of town*.

However, Maling shows that the true criterion at work in these examples is not based on phrase structure category, but is semantic in nature: only what Maling calls *gradable predicates*, those that can hold to a greater or lesser degree, are acceptable as complements of *seem*. Many prepositional phrases do not express gradable predicates, accounting for the unacceptability of example (57b). However, prepositional phrases that denote gradable predicates are acceptable as complements of *seem*:

(58) a. *That suggestion seemed completely off the wall*.

b. *Lee sure seems under the weather.*

Further, as Maling shows, adjective phrases that are not gradable predicates are unacceptable as complements of *seem*. In the following examples, the adjective *irrational* as a description of a mental state is gradable and can be used as the complement of *seems*, while as a technical mathematical term it is not gradable and cannot be used:

(59) a. *Lee seems irrational*.

b. **The square root of two seems irrational*.

In some cases, then, requirements that appear to depend on phrase structure category prove on closer inspection to be functional or semantic in nature.

In other cases, however, the particular constituent structure category of the complement is at issue, and no functional or semantic distinction is involved. The circumstances under which these extra specifications are necessary are rare: subcategorization for a particular phrasal category is a marked exception rather than the general rule. In Chapter 6, Section 4.3, we discuss these cases, showing that the phrase structure category of a complement can be specified in these limited cases.

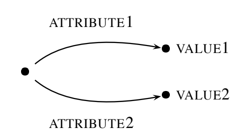
3. FUNCTIONAL STRUCTURE REPRESENTATION

In LFG, functional information is formally represented by the *functional structure* or *f-structure*. Mathematically, the f-structure can be thought of as a function[10] from attributes to values, or equivalently as a set of pairs, where the first member of the pair is an attribute and the second is its value. There is a simple and common way of representing f-structures in tabular form, that is, as a table of attributes and values:[11]

(60) $\begin{bmatrix} \text{ATTRIBUTE1} & \text{VALUE1} \\ \text{ATTRIBUTE2} & \text{VALUE2} \end{bmatrix}$

[10] A function is a special kind of relation which assigns a *unique* value to its argument. For example, the relation between a person and his or her age is a function, since every person has exactly one age. The relation between a person and his or her children is not a function, since some people have no children and some people have more than one child.

[11] In some literature, particularly in Head-Driven Phrase Structure Grammar (see, for example, Pollard and Sag 1994), the objects that are represented in LFG as structures like (60) are instead represented via diagrams such as:



Attributes are labeled arcs in the diagram, and values are nodes. A sequence of attributes, a *path* through the f-structure, corresponds to the traversal of several labeled arcs. A possible source of confusion for those trained within the HPSG framework is that the same formal notation used to represent LFG functional structures in examples like (60) is used to represent *constraints* on structures in HPSG. What is depicted in (60) is not a constraint; it is a formal object.

3.1. Simple F-Structures

The following is a simplified f-structure for the proper noun *David*:

(61) $\begin{bmatrix} \text{PRED} & \text{`DAVID'} \\ \text{NUM} & \text{SG} \end{bmatrix}$

This f-structure does not contain all the syntactic information that *David* contributes. We assume here and elsewhere that the full f-structure representation for the examples we exhibit contains at least the information shown, but may also contain other information not relevant to the particular point under discussion.

The f-structure in (61) contains two attributes: PRED and NUM. The value of NUM is SG, indicating a value of singular for the number feature. The value SG is an *atomic* value.

For the sentence *David yawned*, we have the following f-structure:

(62) $g\begin{bmatrix} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{TENSE} & \text{PAST} \\ \text{SUBJ} & f\begin{bmatrix} \text{PRED} & \text{`DAVID'} \\ \text{NUM} & \text{SG} \end{bmatrix} \end{bmatrix}$

As (62) shows, f-structures can themselves be values of attributes: here, the value of the attribute SUBJ is the f-structure for the subject of the sentence. We can annotate f-structures with labels for subsequent reference; in (62), we have annotated the SUBJ f-structure with the label f and the f-structure for the sentence with the label g.

3.2. Semantic Forms

The value of the PRED attribute is special: it is a *semantic form*. A full discussion of semantic forms will be presented in Chapter 5, Section 2.2; additionally, Chapter 9 presents a more complete discussion of the information that semantic forms represent. In example (62), the semantic form value of the PRED for the f-structure labeled f is 'DAVID', and the value of the PRED feature of g is 'YAWN⟨SUBJ⟩'. The single quotes surrounding a semantic form indicate that its value is *unique*: for example, each instance of use of the word *David* gives rise to a uniquely instantiated occurrence of the semantic form 'DAVID'.

We use English names for semantic forms throughout. For example, we provide the semantic form 'MAN' for the Warlpiri noun *wati* 'man'. This is done for ease of readability and to emphasize the distinction between the semantic form associated with a word and its surface realization; uniform use of Warlpiri names instead of English ones for semantic forms would be equally satisfactory, though generally less clear for an English-speaking audience.

The list of grammatical functions mentioned in a semantic form is called the *argument list*. We discuss its role in determining wellformedness constraints on f-structures in Section 3.6 of this chapter.

3.3. Attributes with Common Values

It is possible for two different attributes of the same f-structure to have the same value. When the value is an *atom* like SG or MASC, rather than an f-structure, we simply repeat the value each time:

(63) $\begin{bmatrix} \text{ATTRIBUTE1} & \text{V} \\ \text{ATTRIBUTE2} & \text{V} \end{bmatrix}$

It is also possible for two different attributes to have the same f-structure as their value. Here the situation is slightly more complex. Recall that an f-structure is a set of pairs of attributes and values: f-structures, like other sets, obey the *Axiom of Extension*, which states that two sets are the same if and only if they have the same members (Partee et al. 1993, section 8.5.8). Thus, two f-structures are indistinguishable if they contain the same attribute-value pairs.[12]

Notationally, it is in some cases clearer to represent two identical f-structures separately, repeating the same f-structure as the value of the two attributes:

(64) $\begin{bmatrix} \text{ATTRIBUTE1} & \begin{bmatrix} \text{A1} & \text{V1} \\ \text{A2} & \text{V2} \end{bmatrix} \\ \text{ATTRIBUTE2} & \begin{bmatrix} \text{A1} & \text{V1} \\ \text{A2} & \text{V2} \end{bmatrix} \end{bmatrix}$

Care must be taken if a *semantic form*, the value of the attribute PRED, is repeated. Since each instance of a semantic form is unique, a repeated semantic form must be explicitly marked with an index to indicate identity; see Chapter 5, Section 2.2.1 for more discussion of this point. If no such index appears, the two semantic forms are assumed to be different.

In other cases, it may be easier and more perspicuous not to repeat the f-structure, but to use other notational means to indicate that the same f-structure

[12] This view of f-structures is different from the view of similar structures in HPSG (Pollard and Sag 1994); the attribute-value structures of HPSG are *graphs*, not set-theoretic objects. On the HPSG view, two attribute-value structures can contain the same attributes and values and can nevertheless be different structures. To state the same point in a different way: HPSG relies on a *type-token* distinction in attribute-value structures (Shieber 1986), meaning that two attribute-value structures are of the same *type* if they have the same set of attributes and values, but may be different *tokens* of that type. In the set-theoretic view of LFG, the Axiom of Extension precludes a type-token distinction, so two f-structures that have the same attributes and values are not distinguished.

appears as the value of two different attributes. We can accomplish this by drawing a line from one occurrence to another, a common practice in LFG literature; this notation conveys exactly the same information as in (64):

(65)
$$\begin{bmatrix} \textsc{attribute1} & \begin{bmatrix}\textsc{a1} & \textsc{v1}\\ \textsc{a2} & \textsc{v2}\end{bmatrix} \\ & \\ \textsc{attribute2} & \end{bmatrix}$$

This convention is notationally equivalent to another way of representing the same structure:

(66)
$$\begin{bmatrix} \textsc{attribute1} & \boxed{1}\begin{bmatrix}\textsc{a1} & \textsc{v1}\\ \textsc{a2} & \textsc{v2}\end{bmatrix} \\ & \\ \textsc{attribute2} & \boxed{1} \end{bmatrix}$$

There is no substantive difference between these two conventions; following LFG tradition, we will generally represent identical values for two features by drawing a line connecting the two values, as in (65).

3.4. Sets

Sets are also valid structures, and may appear as values of attributes. Sets are often used to represent structures with an unbounded number of elements. For instance, there is in principle no limit to the number of modifiers that can appear with any phrase, and so the value of the ADJ feature is the set of all modifiers that appear:

(67) *David yawned quietly.*
$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{yawn}\langle\textsc{subj}\rangle\text{’} \\ \textsc{tense} & \textsc{past} \\ \textsc{subj} & \begin{bmatrix}\textsc{pred} & \text{‘David’}\\ \textsc{num} & \textsc{sg}\end{bmatrix} \\ \textsc{adj} & \left\{ \begin{bmatrix}\textsc{pred} & \text{‘}\textsc{quietly}\text{’}\end{bmatrix} \right\} \end{bmatrix}$$

In (67) only a single modifier appears, but other sentences may contain more modification:

(68) *David yawned quietly yesterday.*
$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{yawn}\langle\textsc{subj}\rangle\text{’} \\ \textsc{tense} & \textsc{past} \\ \textsc{subj} & \begin{bmatrix}\textsc{pred} & \text{‘David’}\\ \textsc{num} & \textsc{sg}\end{bmatrix} \\ \textsc{adj} & \left\{ \begin{array}{l} \begin{bmatrix}\textsc{pred} & \text{‘}\textsc{quietly}\text{’}\end{bmatrix} \\ \\ \begin{bmatrix}\textsc{pred} & \text{‘}\textsc{yesterday}\text{’}\end{bmatrix} \end{array} \right\} \end{bmatrix}$$

Any valid structure can be an element of a set: for example, some sets can have atomic values as their elements. In Chapter 13, we will discuss how these can be used to represent the values of the PERS, GEND, and CASE features in a succinct treatment of feature resolution. The following f-structure for *We yawned* contains the fully specified value {S,H} (mnemonic for Speaker and Hearer) of the PERS feature of the first person subject *we*:

(69) *We yawned.*
$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{yawn}\langle\textsc{subj}\rangle\text{’} \\ \textsc{tense} & \textsc{past} \\ \textsc{subj} & \begin{bmatrix}\textsc{pred} & \text{‘}\textsc{pro}\text{’}\\ \textsc{pers} & \{\textsc{s},\textsc{h}\} \\ \textsc{num} & \textsc{pl}\end{bmatrix} \end{bmatrix}$$

3.5. Sets With Additional Properties

Since there is no limit to the number of conjuncts in a coordinate structure, we also use sets in their representation. Sets representing coordinate structures are special in that the set as a whole is a *hybrid object* that can have its own attributes and values as well as having elements; we will discuss this further in Chapter 13.

As shown above, we represent sets in curly brackets that contain the element f-structures. If a set has additional attributes, we enclose the set in square brackets and list the attributes and values of the set within the square brackets. For example, if a set f has the attribute a with value v it looks like this:

(70)
$$f\begin{bmatrix} a & v & \\ \{ & \} & \end{bmatrix}$$

In the following example, the conjuncts of the coordinate subject *David and Chris* are each singular, but the coordinate structure as a whole is a plural phrase. Thus, the set bears the feature NUM with value PL:

(71) *David and Chris yawn*.

$$\begin{bmatrix} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{TENSE} & \text{PRES} \\ \text{SUBJ} & \begin{bmatrix} \text{NUM} & \text{PL} \\ & \left\{ \begin{matrix} \begin{bmatrix}\text{PRED} & \text{`DAVID'} \\ \text{NUM} & \text{SG}\end{bmatrix} \\ \\ \begin{bmatrix}\text{PRED} & \text{`CHRIS'} \\ \text{NUM} & \text{SG}\end{bmatrix}\end{matrix}\right\} \end{bmatrix}\end{bmatrix}$$

3.6. Wellformedness Conditions on F-Structures

F-structures are required to meet certain wellformedness conditions: Completeness, Coherence, and Consistency (Kaplan and Bresnan 1982). The Completeness and Coherence conditions ensure that all the arguments of a predicate are present and that there are no additional arguments that the predicate does not require. The Consistency condition ensures that each attribute of an f-structure has a single value. We also discuss these requirements in Chapter 5, Section 2.2.

3.6.1. Completeness

The Completeness requirement tells us what is wrong with a sentence like:

(72) **David devoured*.

Intuitively, some required material is missing from a sentence that is incomplete. The required material is specified as a part of the value of the PRED feature, the semantic form. The PRED and semantic form for a verb like *devoured* are:

(73) $\begin{bmatrix} \text{PRED} & \text{`DEVOUR}\langle\text{SUBJ,OBJ}\rangle\text{'}\end{bmatrix}$

The *argument list* of a semantic form is a list of *governable grammatical functions*[13] that are *governed*, or mentioned, by the predicate: in example (73), *devour* governs the grammatical functions SUBJ and OBJ. Example (72) contains a SUBJ but no OBJ; this accounts for its unacceptability according to the Completeness requirement.

Previous LFG literature has contained a variety of notations for the argument list. In the notation employed here, the argument list consists of a list of names

[13]Recall from Section 1.2 of this chapter that the governable grammatical functions are:
SUBJ OBJ OBJ_θ XCOMP COMP OBL_θ

of governable grammatical functions. In other work, the argument list is sometimes depicted as a list of f-structures which are the values of the subcategorized functions:

(74) $$\begin{bmatrix} \text{PRED} & \text{`YAWN}\langle\_\_\rangle\text{'} \\ \text{TENSE} & \text{PAST} \\ \text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{`DAVID'} \\ \text{NUM} & \text{SG}\end{bmatrix}\end{bmatrix}$$

It is also common for the argument list to be represented in the following way, where ($\uparrow$ SUBJ) represents the subject f-structure, as explained in Chapter 5, Section 3.1:

(75) $$\begin{bmatrix} \text{PRED} & \text{`YAWN}\langle(\uparrow\ \text{SUBJ})\rangle\text{'} \\ \text{TENSE} & \text{PAST} \\ \text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{`DAVID'} \\ \text{NUM} & \text{SG}\end{bmatrix}\end{bmatrix}$$

These notational variants are equivalent, though technically the variant shown in (75) is incorrect, since it contains the uninstantiated f-structure metavariable $\uparrow$; here, we choose the more succinct representation in (62) to save space and make the f-structures more readable.

There is a difference between grammatical functions that appear inside the angled brackets and those that appear outside. In (73), the functions SUBJ and OBJ appear inside the brackets. This indicates that the SUBJ and OBJ are semantic as well as syntactic arguments of *devour*, contributing to its meaning as well as filling syntactic requirements. In contrast, the semantically empty subject *it* of a verb like *rain* makes no semantic contribution; thus, the SUBJ function appears outside the angled brackets of the argument list of the semantic form of *rain*:

(76) *It rained*.

$$\begin{bmatrix} \text{PRED} & \text{`RAIN}\langle\rangle\text{SUBJ'}\end{bmatrix}$$

Similarly, the SUBJ argument of the verb *seem* is not a semantic argument of that verb and appears outside the angled brackets:

(77) *It seemed to rain*.

$$\begin{bmatrix} \text{PRED} & \text{`SEEM}\langle\text{XCOMP}\rangle\text{SUBJ'}\end{bmatrix}$$

This intuitive difference is reflected in the formal requirement that arguments of a predicate that appear inside angled brackets must contain a PRED attribute whose value is a semantic form; this is not required for arguments outside angled brackets.

Following Kaplan and Bresnan (1982), the Completeness requirement can be formally defined as follows:

(78) Completeness:

An f-structure is *locally complete* if and only if it contains all the governable grammatical functions that its predicate governs. An f-structure is *complete* if and only if it and all its subsidiary f-structures are locally complete.

Chapter 9 will provide further discussion of the role of the PRED feature in ensuring syntactic wellformedness and its place in the theory of the syntax-semantics interface.

3.6.2. Coherence

The Coherence requirement disallows f-structures with extra governable grammatical functions that are not contained in the argument list of their semantic form:

(79) **David yawned the sink*.

The f-structure for this sentence is ill-formed:

(80) Ill-formed f-structure:

$$\begin{bmatrix} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{`DAVID'}\end{bmatrix} \\ \text{OBJ} & \begin{bmatrix}\text{PRED} & \text{`SINK'}\end{bmatrix} \end{bmatrix}$$

The governable grammatical function OBJ is present in this f-structure, though it is not governed by the semantic form of *yawn*. Consequently, the f-structure is incoherent.

Of course, the Coherence requirement applies only to *governable* grammatical functions, not functions that are ungoverned, such as modifying adjuncts. The following f-structure is perfectly coherent. Besides the single governable function SUBJ, it contains a modifier ADJ, which is not a governable function:

(81) *David yawned yesterday.*

$$\begin{bmatrix} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{`DAVID'}\end{bmatrix} \\ \text{ADJ} & \left\{ \begin{bmatrix}\text{PRED} & \text{`YESTERDAY'}\end{bmatrix} \right\} \end{bmatrix}$$

Coherence requires every f-structure bearing a governable grammatical function to be governed by some predicate: that is, every governable grammatical function that is present in an f-structure must be mentioned in the argument list of the PRED of that f-structure. The following f-structure is incoherent, since there is no PRED in the larger f-structure whose argument list contains OBJ:

(82) Ill-formed f-structure:

$$\begin{bmatrix} \text{OBJ} & \begin{bmatrix}\text{PRED} & \text{`DAVID'}\end{bmatrix} \end{bmatrix}$$

Note that it is not a violation of any condition for more than one predicate to govern an f-structure with a semantic form. In fact, this is a common situation with "raising" verbs like *seem*, whose subject is also the subject of its XCOMP argument (see Chapter 12):[14]

(83) *David seemed to yawn*.

$$\begin{bmatrix} \text{PRED} & \text{`SEEM}\langle\text{XCOMP}\rangle\text{SUBJ'} \\ \text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{`DAVID'}\end{bmatrix} \\ \text{XCOMP} & \begin{bmatrix}\text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \end{bmatrix} \end{bmatrix}$$

The line connecting the f-structure for *David* to the SUBJ position of *seem* indicates that the same f-structure is the value of two different attributes: it is both the SUBJ of *seem* and the SUBJ of *yawn*. Coherence is satisfied for both predicates: each requires a SUBJ, and this requirement is satisfied for each verb.

It is usual but not necessary for the argument list of a predicate to mention grammatical functions, expressions of length one, and not lists of functions or paths through the f-structure. In some treatments of subcategorized oblique phrases, however, the argument list of a predicate contains expressions, such as OBL_{ON} OBJ, of length greater than one; see, for example, Levin (1982) and Falk (2001):

(84) *David relied on Chris*.

$$\begin{bmatrix} \text{PRED} & \text{`RELY}\langle\text{SUBJ,OBL}_{\text{ON}}\ \text{OBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{`DAVID'}\end{bmatrix} \\ \text{OBL}_{\text{ON}} & \begin{bmatrix}\text{OBJ} & \begin{bmatrix}\text{PRED} & \text{`CHRIS'}\end{bmatrix}\end{bmatrix} \end{bmatrix}$$

This f-structure is coherent because the governable grammatical functions it contains are mentioned in the argument list of *rely*. That is, '$\text{RELY}\langle\text{SUBJ,OBL}_{\text{ON}}\ \text{OBJ}\rangle$'

[14]Since the subject of *seem* is a syntactic but not a semantic argument of the *seem* predicate, the SUBJ in the value of the PRED attribute of *seem* appears outside the angled brackets, as explained in Section 3.6.1 of this chapter.

governs the OBJ of the oblique function OBL_{ON}. We do not adopt this treatment of oblique phrases here, but merely display an example to illustrate this possibility.

The Coherence requirement can be formally defined as follows (Kaplan and Bresnan 1982):

(85) Coherence:

An f-structure is *locally coherent* if and only if all the governable grammatical functions that it contains are governed by a local predicate. An f-structure is *coherent* if and only if it and all its subsidiary f-structures are locally coherent.

3.6.3. CONSISTENCY

The Consistency requirement, or Uniqueness Condition, reflects the functional (as opposed to relational) nature of the f-structure. An attribute of an f-structure may have only one value, not more (Kaplan and Bresnan 1982):

(86) Consistency:

In a given f-structure a particular attribute may have at most one value.

This requirement disallows f-structures satisfying incompatible constraints:

(87) **The boys yawns*.

Ill-formed f-structure:

$$\begin{bmatrix} \text{PRED} & \text{‘YAWN}\langle\text{SUBJ}\rangle\text{’} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{‘BOYS’} \\ \text{NUM} & \text{SG/PL} \end{bmatrix} \end{bmatrix}$$

The SUBJ noun phrase *the boys* is a plural phrase, but the verb *yawns* requires its subject to be singular. These two requirements cannot be simultaneously met: the value of the attribute NUM must be either SG or PL, and it cannot have both values at the same time.

4. THE AUTONOMY OF FUNCTIONAL ORGANIZATION

LFG does not assume that abstract grammatical functions are defined in terms of their phrase structural position in the sentence or in terms of morphological properties like casemarking; instead, they are primitive concepts of the theory. However, there is also clear evidence for structure at other levels: for example,

there is abundant evidence for morphological and phrasal organization and structure. Given this, one might conclude that constituent structure is the only structure with a firm linguistic basis, and that the appearance of abstract grammatical functions is actually only an illusion. On this view, the generalizations that traditional grammarians assumed are actually derivative of phrasal organization and structure. We will see in the following that this view is misguided: attempts to define functional structure in terms of morphological or phrase structure concepts do not succeed.

4.1. Grammatical Functions Defined?: Casemarking

It is clear that arguments of predicates have certain superficial morphological properties, and it is equally clear that it is not possible to define grammatical functions in terms of these properties. A cursory look at languages with complex casemarking systems is enough to show that the relation between case and grammatical function is not at all straightforward.

Examples given in Section 1.6 of this chapter show that it is possible to demonstrate a correlation between grammatical function and casemarking in Malayalam: if an argument is ACC, it is an object. However, the overall picture is much more complex; Mohanan (1982) argues convincingly against defining grammatical functions in terms of superficial properties like case. Objects in Malayalam are marked ACC if animate, NOM if inanimate:

(88) a. Nominative subject, object:

kuṭṭi waat̲il aṭaccu
child.NOM door.NOM closed
‘The child closed the door.’

b. Nominative subject, accusative object:

kuṭṭi aanaye kaṇṭu
child.NOM elephant.ACC saw
‘The child saw the elephant.’

In Malayalam, then, there is clearly no one-to-one relation between casemarking and grammatical function, since a grammatical function like OBJ is marked with one of a variety of cases.

Similarly, arguments that can be shown to bear the SUBJ function in Icelandic are marked with a variety of cases, as shown by Andrews (1982). These cases also appear on arguments filling nonsubject grammatical functions; for instance, as examples (89a) and (89b) show, ACC case can appear on both subjects and objects, and examples (89c) and (89d) show that subjects can bear other cases as well:

(89) a. Accusative subject:

Hana dreymdi um hafið.
She.ACC dreamed about sea.DEF
'She dreamed about the sea.'

b. Accusative object:

Stúlkan kyssti drengina.
girl.NOM kissed boys.ACC
'The girl kissed the boys.'

c. Dative subject:

Bátnum hvolfdi.
boat.DEF.DAT capsized
'The boat capsized.'

d. Genitive subject:

Verkjanna gætir ekki.
pains.DEF.GEN is.noticeable not
'The pains are not noticeable.'

In sum, the relation between grammatical function and case is complex. Even when there is a close relation between case and grammatical function, as discussed in Section 1.6 of this chapter, a clear and explanatory description of case-marking and other morphosyntactic properties is best obtained by reference to abstract functional properties.

4.2. Grammatical Functions Defined?: Constituent Structure

Another visible, easily testable property of languages is their surface phrase structure. Given the necessity for this structure, one might claim that grammatical functions are not universally manifest, but instead that the appearance of grammatical functions in a language like English is due to the fact that grammatical functions are associated with certain phrasal configurations in English syntax: in a nutshell, English has subjects and objects because English is configurational. This claim entails that nonconfigurational languages would not be expected to exhibit the same abstract functional relations.

Warlpiri is a language whose phrasal syntactic structure is completely different from that of languages like English. Warlpiri (like many Australian languages) is known for displaying "nonconfigurational" properties, including free word order and "discontinuous phrases." The following Warlpiri sentences involve permutations of the same words; they are all grammatical and have more or less the same meaning (Hale 1983, page 6):

(90) a. *ngarrka-ngku ka wawirri panti-rni*
man-ERG AUX kangaroo spear-NONPAST
'The man is spearing the kangaroo.'

b. *wawirri ka panti-rni ngarrka-ngku*
kangaroo AUX spear-NONPAST man-ERG

c. *panti-rni ka ngarrka-ngku wawirri*
spear-NONPAST AUX man-ERG kangaroo

It would be difficult to find a language less like English in its phrase structure configurational properties. Thus, Warlpiri would seem to be a good candidate to test the hypothesis that evidence for grammatical functions can be found only in English-like configurational languages.

However, as Hale (1983) demonstrates, languages like Warlpiri do show evidence of abstract grammatical relations, just as English-like configurational languages do. Hale discusses person marking, control, and interpretation of reflexive/reciprocal constructions, showing that constraints on these constructions are not statable in terms of surface configurational properties. Simpson and Bresnan (1983) and Simpson (1991) provide further evidence that properties like control in Warlpiri are best stated in terms of abstract functional syntactic relations. In particular, Simpson and Bresnan (1983) examine the *karra*-construction, in which the subject of a subordinate clause with subordinate clause affix *karra* is controlled by the subject of the matrix clause:

(91) *ngarrka ka wirnpirli-mi [karli jarnti-rninja-karra]*
man.ABS AUX whistle-NONPAST boomerang.ABS trim-INF-COMP
'The man is whistling while trimming a boomerang.'

As Simpson and Bresnan show, the controller subject may be discontinuous or absent, and it may be marked with NOM, ABS, or ERG case. The correct generalization about this construction involves the abstract grammatical function SUBJ of the controller, not any of its surface configurational properties.

Thus, even in a language that appears to have completely different phrase structure properties from English, and which has been analyzed as "nonconfigurational," evidence for abstract functional syntactic relations is still found. The hypothesis that functional structure is epiphenomenal of surface configurational properties is not viable. This position is fairly widely accepted, although proposals for the representation of abstract syntactic structure are more variable; in Chapter 4, Section 5, we will discuss proposals by Hale and others for representing abstract syntactic structure, relations like SUBJ and OBJ, by means of phrase structure trees.

4.3. Grammatical Functions Defined?: Semantic Composition

Dowty (1982) proposes to define grammatical functions like SUBJ and OBJ in compositional semantic terms, by reference to order of combination of a predicate with its arguments: a predicate must combine with its arguments according to a functional obliqueness hierarchy, with the SUBJ defined as the last argument to combine with the predicate. This approach is also adopted by Gazdar et al. (1985) for Generalized Phrase Structure Grammar, and has to some extent carried over to Head-Driven Phrase Structure Grammar (Pollard and Sag 1994).

There are several ways in which an approach like Dowty's, where grammatical functions are defined as an ordering on the arguments of a predicate, might lead to incorrect predictions. First, if the order of semantic composition is very closely tied to the order of composition of the surface configurational structure, this approach would predict that the subject could not intervene between the verb and the object; of course, this prediction is not correct, since many languages exhibit VSO word order. The theory that Dowty and most other adherents of this position advocate does not suffer from this difficulty, however, since the hypothesized relation between the surface order of arguments in a sentence and the order of semantic composition is more complex.

A more subtle problem does arise, however. It is not clear that such an approach can make certain distinctions that are necessary for syntactic analysis: in particular, it does not seem possible to distinguish between predicates that take the same number of arguments with the same phrasal categories. For example, any two-argument verb that requires a noun phrase subject and a sentential complement should behave like any other such verb.

However, there are languages in which some sentential complements bear the OBJ function, while others bear the COMP function, as discussed in Section 1.7 of this chapter. In a theory like LFG, this distinction is reflected in a difference in the grammatical function of the sentential complement; some sentential complements are OBJ, and others are COMP. It is not clear how such a distinction can be drawn in a theory in which grammatical functions are defined purely by order of combination with the verb.

Dowty also argues against theories which, like LFG, assume that grammatical functions are undefined primitives by claiming that in his approach "grammatical relations play an important role in the way syntax relates to compositional semantics." This statement is a non sequitur. In LFG, grammatical functions are primitive concepts and also play an important role in compositional semantics and the syntax-semantics interface. Indeed, this is the topic of Chapter 9 and the following chapters (see also Bresnan 1982a, page 286).

Leaving aside these difficulties, there is a strong degree of similarity between theories that define grammatical functions in terms of abstract properties such as order of semantic combination and theories like LFG, in which grammatical functions are not definable in terms of phrasal or argument structure. For both types of theories, grammatical functions are abstract and are analyzed independently from phrasal and other structures.

5. FURTHER READING AND RELATED ISSUES

Within LFG, there has been more discussion of grammatical functions and functional structure than can be summarized in a brief space. Besides the works cited earlier, Andrews (1985) provides a good overview of the grammatical functions of nominals. Butt et al. (1999) provide a general overview of English, French, and German functional and phrasal structure; in particular, they discuss constructions involving the open complement XCOMP and propose a new grammatical function, PREDLINK, for closed nonverbal complements. Falk (2000) also discusses the theory of grammatical functions, proposing the addition of a new grammatical function PIVOT. We will discuss other work on functional structure and its relation to other linguistic structures in the following chapters.

9

MEANING AND SEMANTIC COMPOSITION

We now embark on an exploration of the theory of the relation between syntax and meaning, examining how the meaning of an utterance is determined on the basis of its syntactic structure. Early work in LFG proposed that the semantic form value of the f-structure PRED represented certain aspects of the meaning of the f-structure. More recent work assumes the existence of a *semantic structure*, related to the f-structure by a correspondence function. In this chapter, we briefly review some previous LFG approaches to semantics and the syntax-semantics interface. We then present the *glue approach* to semantic composition, the approach we adopt in the remainder of the book. This approach gives a firm theoretical foundation for the discussions in the next five chapters.

1. SYNTAX AND SEMANTIC INTERPRETATION

The central problem of semantic interpretation is plain: people have no trouble understanding the meanings of sentences in their language that they have never

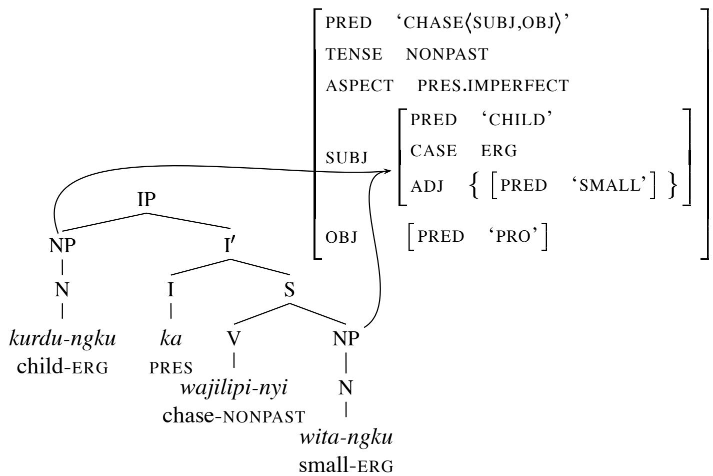
heard before. Thus, people must be able to determine the meaning of a novel sentence on the basis of the meanings of its component parts. The idea that the meanings of larger pieces are assembled from the meanings of the smaller pieces that make them up is known as the Principle of Compositionality, and is generally attributed to Gottlob Frege (though the accuracy of this attribution has been disputed; see, for example, Janssen 1997). An adequate treatment of linguistic meaning requires, then, a theory of the meanings of the most basic units of a sentence, together with a theory of how these meanings are put together.

A commonly accepted version of the Principle of Compositionality is the *rule-to-rule* hypothesis, which states that “a very close relation is supposed to exist between the rules of the syntax and the rules of the semantics” (Bach 1989). This means that each syntactic rule for combining syntactic units to form a larger syntactic unit corresponds to a semantic rule that tells how to put the meanings of those units together to form the meaning of the larger unit. The syntactic rules in question are often assumed to be phrase structure rules, so that instructions for combining meanings are paired with instructions for forming constituent structure phrases.

However, this version of the rule-to-rule hypothesis is actually just one way of enforcing an orderly theory of semantic composition, one in which the intuition that the meaning of a whole depends on the meanings of its parts is made explicit by defining the relevant parts as phrase structure constituents. In fact, research on the syntax-semantics interface and semantic composition in LFG has shown that we can remain faithful to the Principle of Compositionality without assuming that rules for putting meanings together must depend on phrasal primitives such as linear order and phrasal dominance.

Since the inception of semantic research in LFG, researchers have presented convincing arguments that semantic composition should proceed mainly by reference to functional structure rather than constituent structure organization. As argued by Fenstad et al. (1987, Chapter 2), the units that are primarily relevant for semantic composition are units at f-structure and not necessarily at c-structure. For example, as we have seen, a semantic unit may correspond to discontinuous portions of the c-structure tree. Example (23) of Chapter 4, repeated in example (1) (page 219), shows that the Warlpiri analog of the English phrase *small child* need not form a c-structure constituent; the noun *kurdu-ngku* ‘child’ appears at the beginning of the sentence, while its modifier *wita-ngku* ‘small’ appears at the end. However, rules for semantic composition in both English and Warlpiri treat the subject of the Warlpiri sentence *kurdu-ngku ka wajilipi-nyi wita-ngku* and the English sentence *The small child is chasing it* as an f-structure constituent and as a semantic unit; in fact, the rules for semantic composition in the two languages are remarkably similar, considering the great differences between the two languages at the constituent structure level. Guiding semantic composition by reference to f-structure and not c-structure relations brings out and clarifies crosslinguistic

(1) *kurdu-ngku ka wajilipi-nyi wita-ngku*
child-ERG PRES chase-NONPAST small-ERG
'The small child is chasing it.'



commonalities in principles of semantic composition, commonalities that would otherwise be obscured by properties of the more variant constituent structure.

Even given the centrality of functional structure in semantic composition, however, it must be kept in mind that semantic composition does not depend solely on functional structure. For example, as pointed out by Halvorsen (1983) and Fenstad et al. (1987), intonation has a strong effect in determining semantic interpretation; intonational information is represented at prosodic structure, a structure that is related to but separate from the c-structure. Information structure, described in Chapter 7, Section 3, also plays a central role in semantic interpretation. We will not examine constraints on meaning assembly defined at nonsyntactic levels of representation in the following, but it is worth keeping in mind that these other levels also constrain or contribute to semantic content.

2. SEMANTIC FORMS

As discussed in Chapter 2, Section 3.1, the value of the PRED feature in the f-structure is called a *semantic form*. This nomenclature reveals an early LFG view

of meaning and its relation to f-structure: as discussed in Chapter 8, semantic forms were originally seen as the locus of semantic description. On the view presented by Kaplan and Bresnan (1982), semantic forms represent four types of information (see also Dalrymple et al. 1993):

(2) a. Specification of the semantic relation
b. Mapping of grammatical functions to semantic roles
c. Subcategorization information (the governed grammatical functions)
d. Instantiation to indicate distinctness (predicate uniqueness)

Chapter 8, Section 2 discussed this view of semantic forms, which assumes a semantic form like the one in (3) for the verb *give*:

(3) Semantic form for *give* (Kaplan and Bresnan 1982):

$$\text{`GIVE}\langle \begin{array}{c}\text{SUBJ}\\ \text{—}\\ \text{AGENT}\end{array}, \begin{array}{c}\text{OBJ}\\ \text{—}\\ \text{THEME}\end{array}, \begin{array}{c}\text{OBL}_{\text{GOAL}}\\ \text{—}\\ \text{GOAL}\end{array} \rangle\text{'}$$

This semantic form specifies that the predicate GIVE has three arguments with roles AGENT, THEME, and GOAL; that the AGENT is mapped to SUBJ, the THEME is mapped to OBJ, and the GOAL is mapped to OBL_{GOAL}; that the f-structure for a sentence with this verb must contain a SUBJ, an OBJ, and an OBL_{GOAL} in order for the Completeness and Coherence conditions to be met; and that this use of the verb *give* is distinct from other uses of the same verb, since each use of a semantic form is uniquely indexed (Chapter 5, Section 2.2.1).

More elaborated theories of several of these aspects of semantic forms have emerged in the years since Kaplan and Bresnan's original work. Most obviously, the mapping of grammatical functions to semantic roles has been the focus of much theoretical attention and is discussed in detail in Chapter 8.

Further, the semantic form is no longer assumed to represent semantic relations in f-structure. Instead, the semantic contribution of a verb like *give* is reflected in the semantic structure and its relation to meanings, to be described in this chapter, as well as in argument structure (Chapter 8). This separation leads to a more modular theory, since on this view f-structure is a purely syntactic level of representation, not a mix of syntactic and semantic information. In addition, a more adequate view of meaning and its relation to syntax is thereby available: the original view of the semantic form was inadequate to represent anything but the most basic semantic relations. Semantic forms could not represent many aspects of interpretation, including scope of modifiers, quantification, and notions of coreference.

What, then, is the role of the semantic form value of the PRED feature in the current setting? First, the function of instantiation to indicate distinctness remains.

There are often cases in which a phrase makes a syntactically unique contribution, and the fact that semantic forms are instantiated uniquely for each instance of their use enforces this requirement.

Second, semantic forms represent the array of syntactic arguments that a predicate requires, making explicit the result of the application of mapping principles to the argument structure of a predicate. As discussed in Chapter 8, syntactic and semantic argument structure are not the same; verbs like intransitive *eat* and *rain* illustrate this point:

(4) a. *Chris ate*.

b. *It rained*.

Although *eat* denotes a two-place relation between an eater and an eaten thing, syntactically it has an intransitive use; conversely, *rain* does not take a semantic argument, but is syntactically monovalent. Semantic forms represent the syntactic grammatical functions required by a predicate, whether or not they make a semantic contribution.

3. SEMANTIC STRUCTURE AND MEANING COMPOSITION

Approaches to meaning and the syntax-semantics interface within the LFG framework share a striking degree of commonality: rules for semantic composition are formulated primarily by reference to syntactic predicate-argument structure, the syntactic organization of f-structure; and a theory of either implicit or explicit instructions for combining the meanings of the parts of a sentence into the meaning of the whole, what Fenstad et al. (1987) call a "logical syntax," is based on these f-structure relations.

In the first comprehensive treatment of semantics and its relation to syntax within LFG theory, Halvorsen (1983) proposes a semantic structure that is obtained by analysis of the f-structure, as described in Chapter 7, Section 4.2. The semantic structure that Halvorsen proposes consists of instructions on how to assemble meanings represented as formulas of the intensional logic of Montague (1974b); thus, the semantic structure represents an explicitly stated and clearly worked out theory of semantic composition, a set of instructions for meaning assembly.

Reyle (1988) provides a different view of semantic composition, one that is in some sense more closely tied to c-structure composition but that is interestingly different from the standard assumptions of the rule-to-rule hypothesis. On Reyle's approach, the basic meaning contributions of the daughters in a phrase structure rule are gathered up into a set of contributions associated with the mother node.

These contributions consist of expressions of intensional logic that are indexed by f-structure relations like SUBJ and OBJ. These contributions can combine in different orders, and these different orders can correspond to different meanings — for instance, to different scopes for quantifiers, similar in some respects to the treatment of quantifier scope ambiguity described in Dalrymple et al. (1997b) and Section 8 of this chapter: the order in which meanings are combined does not necessarily mirror the order of phrasal composition, and a freer order is allowed.

Wedekind and Kaplan (1993) and Kaplan and Wedekind (1993) present a theory of semantic interpretation that relies on the *restriction operator*, discussed in Chapter 6, Section 3.4. The restriction operator allows reference to the f-structure that results from removing an attribute and its value from another f-structure. Wedekind and Kaplan's analysis is primarily targeted at a treatment of the semantics of modification, which had proven problematic in various ways in previous approaches. An interesting and important aspect of Wedekind and Kaplan's proposal is that it incorporates a form of *resource accounting*: the semantic argument of a modifier is defined in terms of the meaning that results from removing the modifier from the structure, and the final meaning is obtained by applying the meaning of the modifier to this argument. This means that each modifier is required to make exactly one contribution to the final meaning. In the following, we will see why this property is a particularly desirable one.

These approaches illustrate three important and desirable properties of a theory of semantic composition. First, the theory should incorporate a systematic and explicit theory of how meanings combine, grounded in a thorough understanding of the space of theoretical possibilities, structures, and results. Second, it should not impose an explicit order of composition that is tied to constituent structure organization. Third, it should treat meanings as resources that are accounted for in the course of semantic composition. Section 5 of this chapter introduces an approach to semantic composition and the syntax-semantics interface, the *glue approach*, that meets these conditions.

Before introducing the theory, however, we must decide on a method for representing the meaning of an utterance and its parts; in the next section, we turn to the issue of meaning representation.

4. EXPRESSING MEANINGS

In formulating a theory of the relation between syntax and meaning, one of our first decisions is how to represent the meanings of words and phrases. In this book, we will concentrate primarily on issues related to semantic composition and the syntax-semantics interface. Many details of semantic interpretation do not interact significantly with principles of meaning assembly and semantic composition;

thus, our overall goal will be to use the simplest possible meaning representations that are adequate to represent the semantic distinctions we are interested in.

We will generally use standard predicate logic as a way of expressing meanings.[1] This formal system has several advantages: it is a simple and uncluttered representation, and it is widely known and generally familiar. Further, meanings represented as terms of predicate logic can often be readily translated into the representations used in other semantic theories, so that the use of predicate logic is not unduly limiting or confining. In fact, our predicate logic representations might profitably be viewed as abbreviations for the full semantic representations proposed in other semantic theories. Formally, the only requirement we impose on our system of meaning representation is that it must permit function abstraction and application, with a well-defined notion of variable binding, and predicate logic meets this desideratum.

It is of course possible to work within a different, more expressive theory of meaning representation, such as intensional logic (Montague 1974b), Discourse Representation Theory (Kamp 1981; Kamp and Reyle 1993), or Situation Semantics (Barwise and Perry 1983). Importantly, these semantic theories are fully compatible with the 'glue' approach to semantic composition that we present here. Dalrymple et al. (1999b) provide a short illustrative example of the use of Discourse Representation Structures in a glue setting to represent meanings. Other glue-based approaches to the syntax-semantics interface using intensional logic or Discourse Representation Theory are described in Section 4.2 of this chapter. Since the semantic issues treated in those works are not the main focus of our discussion in this book, we will be content with a simpler system.

The following few pages contain a brief introduction to some basic concepts of predicate logic. Gamut (1991a,b) and Partee et al. (1993, Chapter 7) give a much more complete explication of the concepts introduced below, as well as a full exposition of their formal underpinnings.

4.1. Predicate Logic

The expression in (5) represents the meaning of the proper noun *David*:

(5) *David*

David is a constant representing the individual David. Representing the meaning of a proper noun as an individual constant is a convenient simplification; to do complete justice to the meaning of proper names, a fairly complex theory of individual reference would be required. We stress that such a theory is fully compatible with the glue theory of semantics and meaning assembly that we present and that the constant *David* can be thought of as an abbreviated representation of the fully fleshed-out semantic contribution of the proper name *David*.

We use the expression in (6) to represent the meaning of the sentence *David yawned*:

(6) $\mathit{yawn}(\mathit{David})$

Formally, the expression in (6) indicates that the one-place function *yawn* is applied to *David* — or, to say the same thing in a different way, the predicate *yawn* holds of *David*. This expression means that David yawned, but does not represent many details of the meaning of the sentence, including its tense. Again, when these details are not immediately relevant to our discussion, we will usually omit them.

4.1.1. Lambda Expressions

The expression *yawn* represents a function that takes an argument like *David*. For greater flexibility, we would like to have a general method for constructing functions from other expressions; this is made possible by the use of the *lambda operator* λ, which allows the construction of new functions by abstracting over variables in logical expressions:[2]

(7) Lambda abstraction:

$\lambda X.P$ represents a function from entities represented by X to entities represented by P.

Usually, the expression P contains at least one occurrence of the variable X, and we say that these occurrences are *bound* by the λ lambda operator.

To avoid situations where the same variable name has accidentally been chosen for two different variables, we might sometimes need to rename the variables that are bound by a lambda operator. The expressions in (8a) are equivalent, and so are the ones in (8b):

(8) a. $\lambda X.\mathit{person}(X) \equiv \lambda Y.\mathit{person}(Y)$

b. $\lambda X.\mathit{admire}(X,X) \equiv \lambda Y.\mathit{admire}(Y,Y)$

Besides the equivalences that come from variable renaming, there are many other equivalent ways of writing a function. We will generally try to represent a function in the clearest way possible, which will usually be the simplest and shortest way. For example, in the case of a one-place function like *person*, the shortest

[1] In our discussion of anaphoric binding in Chapter 11 and of noun phrase coordination in Chapter 13, some extensions to predicate logic will be necessary. In particular, to treat anaphoric binding we require a representation of individuals relevant in the current context and a notion of dynamic variable binding; to treat noun phrase coordination we need a basic theory of plurals and group formation. Elsewhere, predicate logic adequately represents the semantic distinctions we need to draw.

[2] A more complete discussion of the lambda operator and the lambda calculus can be found in Gamut (1991b, Chapter 4) and Partee et al. (1993, Chapter 13).

and simplest way is just to write the name of the function *person*. Alternatively, we can apply the function *person* to an argument X that is bound by the λ lambda operator, and we have constructed a one-place function $\lambda X.\textit{person}(X)$ that is the same as the function *person*. The following two expressions are equivalent:

(9) $\lambda X.\textit{person}(X) \equiv \textit{person}$

At times it will be clearer to write a function in this way; for example, writing the function as $\lambda X.\textit{person}(X)$ shows explicitly that it is a function that takes one argument.

Another way of thinking of a function like $\lambda X.\textit{person}(X)$ is that it picks out the set of individuals that are people — that is, the set of individuals X for whom the expression $\textit{person}(X)$ is true. The function $\lambda X.\textit{person}(X)$ is called the *characteristic function* of the set of people. We will sometimes refer to sets and their characteristic functions in our discussions of meaning.

4.1.2. Function Application

As in (6), we can apply a function to its argument:

(10) Function application:

$[\lambda X.P](a)$

The function $\lambda X.P$ is applied to the argument a.

Square brackets around the function expression have been added to make the groupings in this expression explicit. This expression is equivalent to the expression that results from replacing all occurrences of X in P with a. For example, the expression $[\lambda X.\textit{yawn}(X)](\textit{David})$ is equivalent to the expression $\textit{yawn}(\textit{David})$, which is the expression that results from replacing all occurrences of X in $\textit{yawn}(X)$ with *David*:

(11) $[\lambda X.\textit{yawn}(X)](\textit{David}) \equiv \textit{yawn}(\textit{David})$

There is usually at least one occurrence of X in P. If there is more than one occurrence of X, as in example (8b), each occurrence is replaced by the argument of the function.

4.1.3. Types

We assume that the expressions we are working with are *typed*. As shown earlier, we propose the individual constant meaning *David* for the proper name *David*; this meaning has type e (for *e*ntity), the type of individuals:

(12) $\textit{David} : e$

The expression in (12) indicates that the constant *David* is of type e. We assume that there are only two basic types: e is associated with individual-denoting expressions and t (for *t*ruth value) is associated with proposition-denoting expressions, which have a truth value (i.e., which are either true or false). The expression $\textit{yawn}(\textit{David})$ is of type t:

(13) $\textit{yawn}(\textit{David}) : t$

Types of other expressions are built up from these basic types. For example, the type of a one-place relation like *yawn* is:

(14) $\lambda X.\textit{yawn}(X) : \langle e \rightarrow t\rangle$

The function $\lambda X.\textit{yawn}(X)$ is of type $\langle e \rightarrow t\rangle$, a function from expressions of type e (represented by X) to expressions of type t (represented by $\textit{yawn}(X)$). This function is true when applied to any individual that yawned and false otherwise.

The type of a two-place relation like *selected* is:

(15) $\lambda X.\lambda Y.\textit{select}(X,Y) : \langle e \rightarrow \langle e \rightarrow t\rangle\rangle$

This is a function from expressions of type e (represented by X) to functions from expressions of type e (represented by Y) to expressions of type t (represented by $\textit{select}(X,Y)$).

The types we have examined so far are:

(16)

expression	type
David	e
$\textit{yawn}(\textit{David})$	t
$\lambda X.\textit{yawn}(X)$	$\langle e \rightarrow t\rangle$
$\lambda X.\lambda Y.\textit{select}(Y,X)$	$\langle e \rightarrow \langle e \rightarrow t\rangle\rangle$

As we will see, the type of an argument can be important in constraining possibilities for meaning assembly.

4.1.4. Quantification

Since the work of Montague (1974b) and Barwise and Cooper (1981), there has been a great deal of interest in the properties of quantifiers like *every* and *most*. Here we present a brief discussion of quantification; a more complete discussion can be found in Gamut (1991b, Chapter 7), Partee et al. (1993, Chapter 14), and Keenan and Westerståhl (1997). In Section 8 of this chapter, we will discuss how quantifiers are treated in the glue approach adopted in this work.

The noun phrase *everyone* is a quantifier. A sentence like *Everyone yawned* has a meaning that can be represented in the following way:[3]

(17) *Everyone yawned.*

$\textit{every}(X, \textit{person}(X), \textit{yawn}(X))$

The quantifier *every* represents a relation between an individual (here X) and two propositions involving that individual, the proposition $\textit{person}(X)$ and the proposition $\textit{yawn}(X)$. The first proposition corresponds to what is often called the *restriction* of the quantifier *every*, and the second proposition corresponds to the *scope*. The type of a quantifier like *every* is:

(18) *every*: $\langle\langle e \rightarrow \langle t, t\rangle\rangle \rightarrow t\rangle$

This type associates an individual e with a pair of propositions $\langle t, t\rangle$ that involve that individual. Different quantifiers place different requirements on this relation. For example, for $\textit{every}(X, \textit{person}(X), \textit{yawn}(X))$ to be true, any individual X that is a person — for whom $\textit{person}(X)$ is true — must also yawn, satisfying $\textit{yawn}(X)$. In other words, every individual that is a person must also be an individual that yawns.

(19) *Most people yawned.*

$\textit{most}(X, \textit{person}(X), \textit{yawn}(X))$

The quantifier *most* requires that more than half of the individuals X satisfying the proposition $\textit{person}(X)$ must also satisfy the proposition $\textit{yawn}(X)$.

(20) *No person yawned.*

$\textit{no}(X, \textit{person}(X), \textit{yawn}(X))$

The quantifier *no* requires that any individual X who satisfies the proposition $\textit{person}(X)$ must *not* satisfy the proposition $\textit{yawn}(X)$ — that is, there should be no individuals that are people that also yawn.

The restriction of a quantifier — its first propositional argument — is syntactically fixed, given by the meaning of the quantified common noun (*person* or *people* in the examples above) and any modifiers it might have. In contrast, the scope of a quantifier — its second propositional argument — is chosen more freely. As we will discuss in Chapter 12, Section 2.1, example (21) is syntactically unambiguous, with only one c-structure tree and one f-structure. It is semantically ambiguous, however, since the scope of the quantifier can vary:

[3] In our analysis of quantification we use *pair quantifiers*, expressions like the one in (17), instead of standard generalized quantifiers (*every(person,yawn)*). There is a one-to-one correspondence between the two types of quantifiers, as shown by Dalrymple et al. (1991).

(21) *Someone seemed to yawn.*

Reading 1: $\textit{seem}(\textit{a}(X, \textit{person}(X), \textit{yawn}(X)))$
Reading 2: $\textit{a}(X, \textit{person}(X), \textit{seem}(\textit{yawn}(X)))$

According to Reading 1, the proposition $\textit{a}(X, \textit{person}(X), \textit{yawn}(X))$ seems to hold; that is, it seems to be the case that someone yawned, although in fact no one may actually have yawned. In contrast, Reading 2 claims that there is some individual X that satisfies the proposition $\textit{person}(X)$ and that also seemed to yawn, satisfying the proposition $\textit{seem}(\textit{yawn}(X))$. Such examples show that it is not adequate to rely on the f-structure as a representation of the meaning of a sentence; the single f-structure for example (21) corresponds to more than one meaning. Our theory of semantics and the syntax-semantics interface allows us to deduce exactly these two meanings for example (21), given its unambiguous syntactic structure.

This concludes our brief introduction to predicate logic. We have seen that predicate logic provides a basic yet sufficiently expressive way of representing linguistic meaning. This is an advantage from our perspective, since much of our discussion will focus on issues in meaning assembly, and our claims about the meanings of particular constructions will be fairly general.

4.2. Other Semantic Theories

In much LFG work on meaning and semantic composition, specific assumptions about the nature and representation of linguistic meaning and its relation to syntactic structure have been explored, and a close analysis of the semantic contributions of particular phrases or constructions has been the main focus of concern. Work on integrating an LFG view of semantic composition with other semantic theories is important and valuable, since this work not only allows for a fuller exploration of the relation of syntactic structure to meaning, but also makes important contributions to semantic theory and meaning representation.

Since the work of Montague (1970), it has been common to use *intensional logic* to express linguistic meaning. Halvorsen (1983) proposed a theory of the association between f-structures and meanings, outlined briefly in Chapter 7, Section 4.2, which allowed the construction of formulas of intensional logic to represent the meanings of utterances based on their f-structures. Meanings have also been represented as formulas of intensional logic in an LFG setting by Wedekind and Kaplan (1993) and by Dalrymple et al. (1997b).

In other work, the semantic theory of Situation Semantics (Barwise and Perry 1983) is assumed. Fenstad et al. (1987) propose that functional descriptions in rules and lexical entries describe not only the f-structure for an utterance but also a *Situation Schema*, which represents information provided by linguistic form that is relevant for semantic interpretation. Situation Semantics adheres to the *Relational Theory of Meaning*, whereby the meaning of an utterance is a relation between the situation in which an utterance is made — the *utterance situation* — and the situation described by the utterance, the *described situation*. Accordingly, the situation schemata proposed by Fenstad et al. (1987) represent a potentially underdetermined description of the relation between an utterance situation and a described situation. Fenstad et al. provide an extensive treatment of constraints on situation schemata as well as an algorithm for their interpretation. Gawron and Peters (1990) also propose a Situation-Theoretic view of anaphora, quantification, and their interactions from an LFG perspective, and their work includes an appendix containing an LFG grammar for the fragment of English that they treat.

Perhaps the most widely adopted theory of semantics among LFG researchers is Discourse Representation Theory (Kamp 1981; Kamp and Reyle 1993). Discourse Representation Theory assumes that each sentence in a discourse contributes to the construction of a *Discourse Representation Structure* representing the discourse referents that are introduced as well as the conditions they must meet. Frey and Reyle (1983) advanced one of the first proposals for constructing Discourse Representation Structures for utterances based on their f-structures, and this work was continued by Wada and Asher (1986) and Asher and Wada (1988) in their proposals for LFG-based DRS construction. Muskens (1995) also proposes an analysis involving Underspecified Discourse Representation Structures (Reyle 1993) with syntactic assumptions that are very close to LFG.

Within the glue approach to semantic composition that we are about to explore, there is no obstacle to representing linguistic meanings according to these semantic theories. Dalrymple et al. (1997b) discuss quantification and intensionality in the glue approach, using intensional logic to represent meanings. As mentioned earlier, Dalrymple et al. (1999b) briefly discuss the construction of Discourse Representation Structures in a glue setting, where meanings are given as expressions of Lambda DRT (Bos et al. 1994). Van Genabith and Crouch (1999a) provide a detailed and very interesting discussion of different methods for incorporating dynamic and underspecified meaning representations, similar to the structures of Underspecified Discourse Representation Theory, within the glue approach (see also van Genabith and Crouch 1999b).

5. MEANING ASSEMBLY AND LOGICAL 'GLUE'

This section introduces the glue theory of semantic composition and presents some basic examples of meaning assembly in the glue setting. We propose a logically based theory of semantic composition: instructions for combining meanings are stated as premises in a logical deduction. The deduction of the meaning of an utterance proceeds by combining these premises as the logic requires, which means that meaning composition need not proceed according to the rules of phrasal composition. And the logic used to state constraints on meaning combination is a resource logic, *linear logic*, which treats meaning contributions as resources that are accounted for in the meaning deduction. Thus, the theory conforms to the desiderata introduced at the end of Section 3 of this chapter. The theory is often referred to as the *glue approach* because of the role of linear logic in stating how the meanings of the parts of an utterance can be "glued together" to form the meaning of the whole utterance.

5.1. Meaning Specifications and the Projection Architecture

The lexical entry for a proper name like *David* contains at least the syntactic information shown in (22):

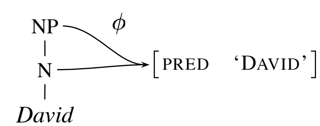
(22) *David* N ($\uparrow$ PRED) = 'DAVID'

We also adopt the following simplified phrase structure rule for NP:

(23) NP $\longrightarrow$ $\underset{\uparrow = \downarrow}{\text{N}}$

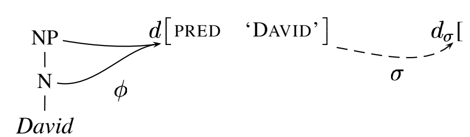
As discussed in Chapter 5, this lexical entry and phrase structure rule give rise to the syntactic structures in (24):

(24)



We now augment our theory with a *semantic structure* and its associated meaning. As described in Chapter 7, a linguistic structure like the semantic structure is related to other linguistic structures by means of a *correspondence function*. Here, the function σ relates f-structures to semantic structures, and we say that the semantic structure is a *projection* of the functional structure. In (25), d_σ is the semantic structure that is related to the f-structure labeled d by the correspondence function σ, represented as a dotted line:

(25)



As noted in Chapter 7, Section 2, there are two common and equivalent notations for the correspondence function:

(26) $d_\sigma \ \equiv \sigma(d)$

In the following, we will use the subscript notation that is used most commonly in recent LFG literature, rather than the parenthesis notation: that is, we will write d_σ rather than $\sigma(d)$ for the semantic structure corresponding to d via the correspondence function σ. Nothing of substance depends on this notational choice; using the parenthesis notation would be equally correct.

We propose the augmented lexical entry in (27) for the proper name *David*. This lexical entry differs from the one in (22) in that the expression *David* : $\uparrow_\sigma$ has been added. No additions or changes to the phrase structure rule in (23) are necessary:

(27) *David* N ($\uparrow$ PRED) = 'DAVID'
David : $\uparrow_\sigma$

The expression *David* : $\uparrow_\sigma$ is called a *meaning constructor*, since it is an expression that tells us how to construct meanings.[4] In this simple case, there is no real meaning construction involved, since the meaning *David* is complete on its own. Other cases are more complex, as we will soon see.

Meaning constructors are pairs, with the left-hand side (the *meaning side*) representing a meaning and the right-hand side (the *glue side*) representing a logical formula over semantic structures corresponding to that meaning. The expression *David* : $\uparrow_\sigma$ says that *David* is the meaning associated with $\uparrow_\sigma$, the semantic projection of the f-structure $\uparrow$. In (25), the f-structure metavariable $\uparrow$ is instantiated to the f-structure labeled d, and so the meaning constructor pairs the meaning *David* with the semantic structure d_σ.

As discussed in Section 4.1.3 of this chapter, meaning expressions are typed; the constant *David* is of type e. We assume that the basic types e and t are associated with semantic structures, since the type of an expression is important in determining how it can combine with other expressions. Types are written on the semantic structure as subscripts enclosed in angled brackets:

(28) *David* : $d_{\sigma\langle e\rangle}$

[4] The meaning constructors we assume in this work are cast in the so-called "Curry-Howard" or "new glue" format, conforming to the proposals made by Dalrymple et al. (1999a). This format departs from much earlier work in the glue framework, including most of the papers collected in Dalrymple (1999), in which the meaning constructor for *David* would have been written as $\uparrow_\sigma \rightsquigarrow$ *David* (read as '$\uparrow_\sigma$ means *David*'). The two formats have different expressive power, and in fact the "new glue" format adopted here is the more constrained of the two; see Dalrymple et al. (1999a) for more discussion of the two formats and the formal differences between them.

When the type of a semantic structure is clear from the context, we will often omit it to reduce notational clutter.

For brevity, we can use the label **[David]** to refer to this meaning constructor. In (29), the label **[David]** refers to the typed meaning constructor *David* : $d_{\sigma\langle e\rangle}$, in which d_σ is a semantic structure of type e and *David* is an individual constant representing the individual named David :

(29) **[David]** *David* : $d_{\sigma\langle e\rangle}$

Using names or labels for meaning constructors proves to be useful for presenting deductions in a more compact form.

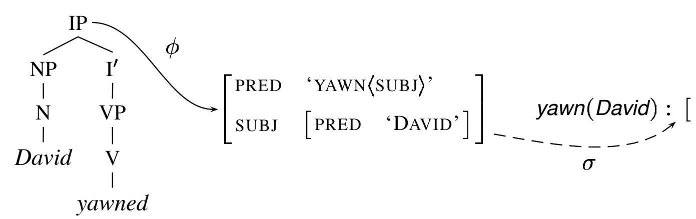
5.2. Assembling Meanings

Some words, like verbs, must combine with other meanings to produce a complete meaning. For example, an intransitive verb combines with its subject to produce a meaning for the sentence. This means that we must provide instructions for combining the meaning of a verb with its arguments to form the meaning of the sentence as a whole. We provide these instructions in logical terms, the "glue language" of linear logic.

5.2.1. EXAMPLE ONE: INTRANSITIVE VERBS

The syntactic structures for the sentence *David yawned*, together with the semantic result we desire, are displayed in (30):

(30) *David yawned*.



The semantic structure for the sentence is related to its f-structure by the correspondence function σ, represented as a dotted line. We are not concerned with the internal structure of the semantic structure here, and so we have represented the semantic structure with no internal attributes or values, as the structure [ ]. Below, we will see cases in which the semantic structure has attributes whose values play a crucial role in meaning deduction.

Let us see how the meaning $\mathit{yawn}(\mathit{David})$ for the sentence *David yawned* is obtained. We propose the following simplified lexical entry for the verb *yawned*:

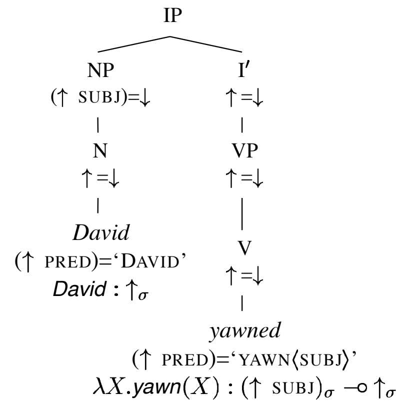
(31) *yawned* V $(\uparrow \text{PRED}) = \text{‘YAWN}\langle\text{SUBJ}\rangle\text{’}$
$\lambda X.\mathit{yawn}(X) : (\uparrow \text{SUBJ})_\sigma \multimap \uparrow_\sigma$

The meaning constructor for *yawned* pairs the meaning for *yawned*, the one-place predicate $\lambda X.\mathit{yawn}(X)$, with the linear logic formula $(\uparrow \text{SUBJ})_\sigma \multimap \uparrow_\sigma$. This formula contains a new expression: the connective $\multimap$ is the *linear implication* symbol of linear logic, which we will discuss in more detail in Section 7 of this chapter. For the moment, we can think of the symbol as expressing a meaning like *if*. . . *then*. . . : in this case, stating that *if* a semantic resource $(\uparrow \text{SUBJ})_\sigma$ representing the meaning of the subject is available, *then* a semantic resource $\uparrow_\sigma$ representing the meaning of the sentence can be produced.

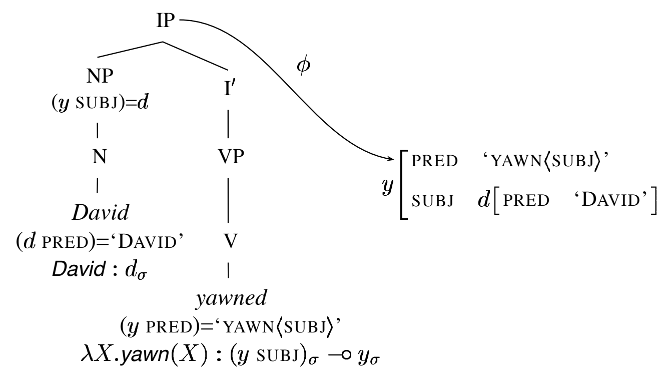
Additionally, the linear implication operator $\multimap$ carries with it a requirement for *consumption* and *production* of semantic resources: the formula $(\uparrow \text{SUBJ})_\sigma \multimap \uparrow_\sigma$ indicates that if a semantic resource $(\uparrow \text{SUBJ})_\sigma$ is found, it is *consumed* and the semantic resource $\uparrow_\sigma$ is *produced*. We also assume that a name like *David* contributes a semantic resource, its semantic structure. In an example like *David yawned*, this resource is consumed by the verb *yawned*, which requires a resource for its SUBJ to produce a resource for the sentence. This accords with the intuition that the verb in a sentence must obtain a meaning for its arguments in order for a meaning for the sentence to be available. Thus, in the linear logic formulas that comprise the glue (right-hand) sides of meaning constructors, semantic structures are treated as resources that are contributed by the words and structures of the sentence.

In example (32) (page 234), we display the syntactic structures described by the lexical entries in (27) and (31), together with the meaning constructors contributed by the words *David* and *yawned*. We assume the standard phrase structure rules for English as outlined in Chapter 5, Section 4.1. In (33), we instantiate the metavariables represented by $\uparrow$ and $\downarrow$ in this tree, using the label y for the f-structure of the entire sentence and d for the SUBJ f-structure. Only the instantiated c-structure annotations that are important for our current discussion are displayed in (33).

(32) *David yawned*.



(33) *David yawned*.



The f-structure for *yawn* in (33) is labeled y, and the f-structure d for *David* is y’s SUBJ. Since $(y \text{ SUBJ}) = d$, we can replace the expression $(y \text{ SUBJ})_\sigma$ by d_σ in the meaning constructors in (33), yielding the instantiated meaning constructors for *David* (labeled **[David]**) and *yawned* (labeled **[yawn]**) in (34):

(34) Meaning constructors for *David yawned*:

[David]	$\mathit{David} : d_\sigma$
[yawn]	$\lambda X.\mathit{yawn}(X) : d_\sigma \multimap y_\sigma$

The meaning (left-hand) sides of the meaning constructors in (34) are familiar from our discussion of predicate logic formulas in Section 4.1 of this chapter. The meaning side of the meaning constructor labeled **[David]** is the proper noun meaning *David*, and the meaning side of the meaning constructor labeled **[yawn]** is the meaning of the intransitive verb *yawned*, the one-place predicate $\lambda X.\textit{yawn}(X)$.

The glue (right-hand) sides of these meaning constructors indicate how these meanings are associated with the different parts of this sentence. The constant *David* is associated with the semantic structure d_σ. The glue side of the meaning constructor labeled **[yawn]** is more complex: as explained earlier, the connective $\multimap$ is the linear implication symbol of linear logic, which we can think of as expressing a meaning like *if* d_σ, *then* y_σ. In other words, the glue side of the meaning constructor labeled **[yawn]** in (34) states that if we can find a resource associated with the semantic structure d_σ, then we can produce a resource associated with the semantic structure y_σ.

We must also provide rules for how the glue side of each of the meaning constructors in (34) relates to the meaning side in a meaning deduction. For simple, nonimplicational meaning constructors like **[David]** in (34), the meaning on the left-hand side is the meaning of the semantic structure on the right-hand side. For implicational meaning constructors like **[yawn]**, which contain the linear implication operator $\multimap$, performing a deductive step on the glue side corresponds to applying a function to its argument on the meaning side:[5]

(35)
$$\frac{\begin{array}{r}X : f_\sigma \\ P : f_\sigma \multimap g_\sigma\end{array}}{P(X) : g_\sigma}$$

Each side of an implicational meaning constructor $P : f_\sigma \multimap g_\sigma$ requires a contribution: the glue side requires as its argument a semantic structure f_σ, and the meaning side requires an argument for the predicate P. When an appropriate resource such as $X : f_\sigma$ is available to provide the appropriate contributions on both the meaning and the glue sides, the result is a complete semantic resource on the glue side and its corresponding meaning on the meaning side. In the case at hand, the pairing of the linear logic formula $d_\sigma \multimap y_\sigma$ with the meaning term $\lambda X.\textit{yawn}(X)$ means that we apply the function $\lambda X.\textit{yawn}(X)$ to the meaning *David* associated with d_σ, obtaining the meaning constructor $\textit{yawn}(\textit{David}) : y_\sigma$ for the sentence.

Besides this rule for function application, we also require a rule of abstraction that allows us to create functions. The rule in (36) allows us to temporarily posit an additional premise in the deduction, a semantic resource f_σ associated with

[5] This is the standard correspondence as defined by the *Curry-Howard Isomorphism* relating propositions like $d_\sigma \multimap y_\sigma$ to terms like $\lambda X.\textit{yawn}(X)$; see Crouch and van Genabith (2000) for more discussion.

the meaning X. A semantic resource hypothesized in this way is notationally distinguished from other premises in that it is enclosed in square brackets: $[f_\sigma]$. If we can successfully perform a deduction (represented by elliptical dots $\vdots$) from this and other meaning constructor premises, producing a semantic resource g_σ with meaning P as in (36), we *discharge* the assumption $X : [f_\sigma]$, and we are left with the meaning constructor $\lambda X.P(X) : f_\sigma \multimap g_\sigma$.

(36)
$$\frac{\begin{array}{c}X : [f_\sigma] \\ \vdots \\ P(X) : g_\sigma\end{array}}{\lambda X.P(X) : f_\sigma \multimap g_\sigma}$$

Intuitively, we have shown that if we are given a resource f_σ, we can then obtain g_σ, exactly the import of the linear logic expression $f_\sigma \multimap g_\sigma$. On the meaning side, we have shown that by providing X, we can produce the meaning $P(X)$ — in other words, that we have proven the existence of a function $\lambda X.P(X)$. We will not use this abstraction rule in the immediately following examples, but it will be helpful in future discussion, especially in our discussion of raising verbs in Chapter 12 and of noun phrase coordination in Chapter 13. The appendix (page 433) contains the full set of rules of deduction for our fragment of linear logic.

With these correspondences between linear logic formulas and meanings, we perform a series of reasoning steps like the following:

(37)

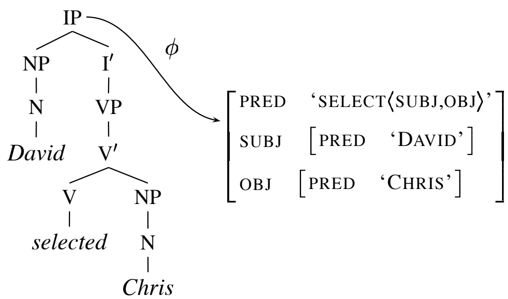
$\textit{David} : d_\sigma$	The meaning *David* is associated with the SUBJ semantic structure d_σ.
$\lambda X.\textit{yawn}(X) : d_\sigma \multimap y_\sigma$	On the glue side, if we find a semantic resource for the SUBJ d_σ, we consume that resource and produce a semantic resource for the full sentence y_σ. On the meaning side, we apply the function $\lambda X.\textit{yawn}(X)$ to the meaning associated with d_σ.
$\textit{yawn}(\textit{David}) : y_\sigma$	We have produced a semantic structure for the full sentence y_σ, associated with the meaning $\textit{yawn}(\textit{David})$.

By using the function application rule and the meaning constructors for *David* and *yawned*, we have deduced the meaning $\textit{yawn}(\textit{David})$ for the sentence *David yawned*, as desired.

5.2.2. Example Two: Transitive Verbs

Our next example of meaning deduction involves a transitive verb; the example differs from the one just presented only in that the verb takes two arguments instead of one. The c-structure and f-structure for the sentence *David selected Chris* are displayed in (38):

(38) *David selected Chris*.



The lexical entry for the transitive verb *selected* is shown in (39):

(39) *selected* V $(\uparrow \text{PRED}) = \text{`SELECT}\langle\text{SUBJ,OBJ}\rangle\text{'}$
$\lambda X.\lambda Y.\mathit{select}(X,Y) : (\uparrow \text{SUBJ})_\sigma \multimap [(\uparrow \text{OBJ})_\sigma \multimap \uparrow_\sigma]$

In the meaning constructor for the transitive verb *selected*, two arguments are required: a resource for the SUBJ, $(\uparrow \text{SUBJ})_\sigma$, and a resource for the OBJ, $(\uparrow \text{OBJ})_\sigma$. The square brackets in this expression are just added to make the groupings in the expression clear: *selected* requires a meaning for its SUBJ, then a meaning for its OBJ, to form a meaning for the sentence.[6] In other words, this formula can be paraphrased as: "If we find a resource for the subject and a resource for the object, we can produce a resource for the entire sentence." The meaning side represents a

[6]The glue side of the meaning constructor in (39) requires the verb to combine with its arguments in a particular order — the SUBJ first, then the OBJ — since this order must respect the order of combination of meanings specified in the lambda expression on the meaning side. The meaning constructor shown in (a) is exactly equivalent to the one in (39) except that the order of argument combination on both the meaning and glue sides is reversed, so that the verb combines with its OBJ first and then its SUBJ:

(a) $\lambda Y.\lambda X.\mathit{select}(X,Y) : (\uparrow \text{OBJ})_\sigma \multimap [(\uparrow \text{SUBJ})_\sigma \multimap \uparrow_\sigma]$

In formal terms, the glue side of this meaning constructor is *logically equivalent* to the glue side of the meaning constructor in (39). In principle, we can choose any order of combination of premises, with no theoretical significance attached to the choice we make. For simplicity, in our discussion here and in the following chapters we will usually choose one particular order in which to combine premises.

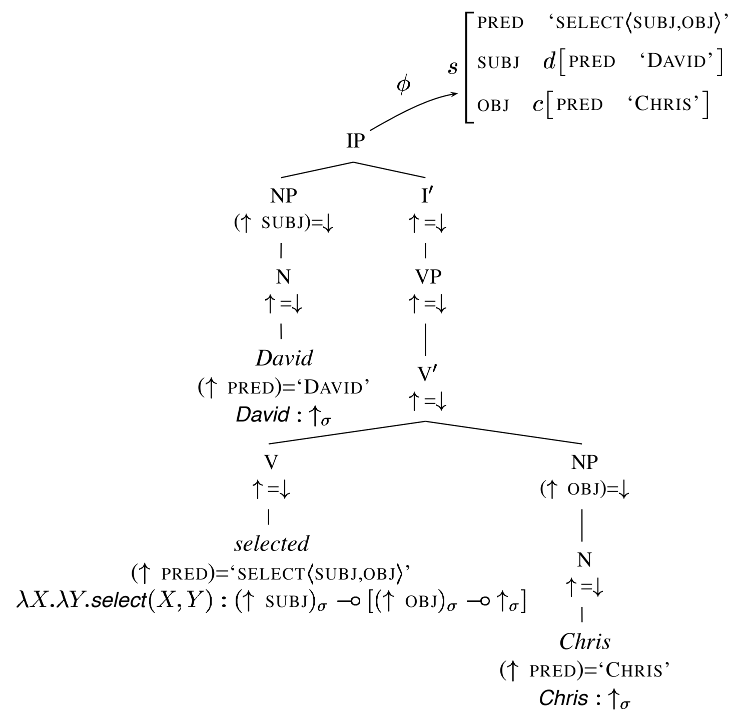
function that requires two arguments and is applied to those arguments to produce a meaning for the sentence.

The lexical entry for *Chris* is analogous to the one for *David*, providing a semantic structure as a resource associated with the meaning *Chris*:

(40) *Chris* N $(\uparrow \text{PRED}) = \text{`CHRIS'}$
$\mathit{Chris} : \uparrow_\sigma$

With these lexical entries for the words in the sentence, we have the following structures:

(41) *David selected Chris*.



Instantiating the $\uparrow$ metavariables in the meaning constructors for *David*, *Chris*, and *select*, we have the following meaning constructors:

(42) Meaning constructor premises for *David selected Chris*:

[David]	$\mathit{David} : d_\sigma$
[Chris]	$\mathit{Chris} : c_\sigma$
[select]	$\lambda X.\lambda Y.\mathit{select}(X,Y) : d_\sigma \multimap [c_\sigma \multimap s_\sigma]$

From these premises, we can make the following logical deduction:

(43) $\mathit{David} : d_\sigma$ — The subject semantic structure d_σ is associated with the meaning *David*.

$\mathit{Chris} : c_\sigma$ — The object semantic structure c_σ is associated with the meaning *Chris*.

$\lambda X.\lambda Y.\mathit{select}(X,Y) : d_\sigma \multimap [c_\sigma \multimap s_\sigma]$
On the glue side, if semantic resources for the subject d_σ and the object c_σ are found, a resource for the sentence can be produced. On the meaning side, the two-place predicate *select* is applied to the subject meaning X and then the object meaning Y to produce the meaning $\mathit{select}(X,Y)$ for the sentence.

$\mathit{select}(\mathit{David},\mathit{Chris}) : s_\sigma$ — We have produced a semantic structure s_σ for the full sentence, associated with the meaning *select*(*David*,*Chris*).

As desired, we have concluded that the meaning for the sentence *David selected Chris* is $\mathit{select}(\mathit{David},\mathit{Chris})$.

In Section 5.1 of this chapter, we noted that meaning constructors can be assigned labels. We will sometimes take advantage of this possibility to present an abbreviated representation of a derivation from a set of premises. For example, we can abbreviate the derivation outlined in (43) in the following way:

(44)

[David]	$\mathit{David} : d_\sigma$
[Chris]	$\mathit{Chris} : c_\sigma$
[select]	$\lambda X.\lambda Y.\mathit{select}(X,Y) : d_\sigma \multimap [c_\sigma \multimap s_\sigma]$

[David], **[Chris]**, **[select]** $\vdash \mathit{select}(\mathit{David},\mathit{Chris}) : s_\sigma$

The final line in (44) represents the derivation of the meaning $\mathit{select}(\mathit{David},\mathit{Chris})$ for the semantic structure s_σ from the premises labeled **[David]**, **[Chris]**, and **[select]**. It contains a new expression $\vdash$, sometimes called the *turnstile*, which

indicates that the conclusion on the right is derivable from the premises on the left. Thus, the final line in (44) means that the conclusion $\mathit{select}(\mathit{David},\mathit{Chris}) : s_\sigma$ is derivable from the premises labeled **[David]**, **[Chris]**, and **[select]**.

In sum, we have used linear logic as a *glue language* to provide instructions on how to glue together or assemble meanings, based on the relations between the syntactic structures they correspond to. The use of this logical language lets us express constraints on meaning combinations in a formally coherent and flexible way, taking advantage of the syntactic relations imposed by the f-structure.

6. CONSTRUCTIONAL MEANING

In the examples just presented, meaning terms are associated with words and not phrase structure rules. In a language like English, annotations on phrase structure rules serve mainly to determine the functional syntactic role of a constituent. For the most part, phrase structure rules play only this syntactic organizing function and do not contribute meaning on their own. This is true for many other languages as well.

However, this generalization is not exceptionless. There are cases in which meaning is associated with a phrasal construction as a whole, where the semantic properties of the construction go beyond the semantic properties of the words it contains. A particularly clear example of meaning associated with phrasal configuration is provided by relative clauses with no relative pronoun, such as:

(45) *the man I met*

In this example, the phrase *I met* is a relative clause modifier of *man*. This information is not lexically associated with either the word *I* or the word *met*. Instead, the interpretation of *I met* as a relative clause is due to the phrasal configuration in which it appears. In Chapter 14, we will propose an analysis of the semantics of relative clauses, and we will see that the phrase structure rule associated with relative clause formation in English can in fact make a contribution to meaning.

The view that meanings can be attached either to lexical items or to c-structure configurations accords with the views of Kaplan and Bresnan (1982, fn. 2), but not with some other proposals. In particular, Halvorsen (1983) proposes that semantic content is introduced only in the lexicon, not by phrase structure rules (see also Bresnan 1982a). In a very interesting discussion of verbless sentences, including the topic-comment construction in Vietnamese and nominal sentences with no copula in Maori, Rosén (1996) shows that attempts to restrict semantic content to appearing only in the lexicon are inadvisable. Phrase structure configurations can be associated with meaning constructors, and these constructors can make an essential contribution to meaning deduction.

7. THE 'GLUE' LANGUAGE: LINEAR LOGIC

We use expressions of *linear logic* (Girard 1987) to give instructions on how to assemble meanings. Here, we informally describe only the properties of the small fragment of linear logic (the *multiplicative fragment*) that we will use.[7]

Intuitively, linear logic is different from classical logic in that premises in a linear logic deduction are treated as resources that must be kept track of, while this is not true in classical logic. Premises in a deduction in classical logic are statements about what is or is not true. In contrast, premises in a linear logic deduction are commodities, occurrences of resources that can be introduced or consumed.

To illustrate this difference, let us assume that we can deduce the statement *You will get wet* from the premises *If it is raining outside, you will get wet* and *It is raining outside* in classical logic:

(46) Classical logic:
If it is raining outside, you will get wet.
It is raining outside.
———————————————
You will get wet.

In classical logic, if a conclusion can be deduced from a set of premises, the same conclusion can still be deduced if additional premises are added:

(47) Classical logic:
If it is raining outside, you will get wet.
It often rains in March.
It was raining yesterday.
It is raining outside.
———————————————
You will get wet.

In contrast, linear logic does not allow the same conclusion to be deduced when additional premises are introduced. Instead, propositions in linear logic can be thought of as resources, and an economic metaphor is sometimes used.

For instance, we can use the symbol \$1 for the proposition that you have a dollar, $\$1 \multimap$ *apple* for the linear logic proposition that if you have \$1, you can get an apple, and *apple* for the proposition that you have an apple. The following is valid in linear logic:

(48) $[\$1 \multimap \textit{apple}],\ \$1 \vdash \textit{apple}$

This can be read as:

[7] In this section, we describe only the properties of the linear implication operator $\multimap$. In Chapter 11 we introduce the *multiplicative conjunction* operator $\otimes$, and in Chapter 13 we introduce the *of course* operator !. Proof rules for our fragment of linear logic are given in the appendix (page 433).

(49) *If you have \$1, you can get an apple.*
You have \$1.
———————————————
You can get an apple.

Just as in the real world, it is not possible to get two apples with \$1, or to still have \$1 as well as the apple:

(50) INCORRECT (obtaining two apples with \$1):
$[\$1 \multimap \textit{apple}], \$1 \vdash \textit{apple}, \textit{apple}$

INCORRECT (obtaining an apple while keeping \$1):
$\$1, [\$1 \multimap \textit{apple}] \vdash \$1, \textit{apple}$

More schematically, inferences in linear logic work in the following way:

(51) INCORRECT: $A \vdash A, A$
We cannot deduce A, A from A.
A resource cannot be duplicated.

INCORRECT: $A, B \vdash A$
We cannot deduce A from A, B.
A resource cannot be discarded.

INCORRECT: $A, [A \multimap B] \vdash A, B$
The resource A is consumed by $A \multimap B$ to conclude B.
A resource is consumed by an implication.

INCORRECT: $A, [A \multimap B] \vdash A \multimap B, B$
Both A and $A \multimap B$ are consumed in concluding B.
A linear implication is also a resource and is consumed in the deduction.

CORRECT: $A, [A \multimap B] \vdash B$

This resource-sensitivity of linear logic allows us to model the meaning contributions of words as *semantic resources* that must be accounted for. The meaning of a sentence is deduced from the meanings of its component parts; it would be incorrect to deduce the same meaning for the sentence if words or phrases are added or subtracted. Each word or phrase makes a unique contribution that must be reflected in the final meaning of the sentence, and meanings cannot be arbitrarily duplicated, added, or discarded.

7.1. Semantic Completeness and Coherence

Formally, we say that a meaning derivation for an utterance is *semantically complete* if a meaning derivation from the premises contributed by the meaning-bearing items in the sentence produces a meaning for the semantic structure for the utterance that does not contain any unsaturated expressions (that is, in which all of the meaning contribution requirements are satisfied). If no such meaning can be produced, some required material is missing and the utterance is *semantically incomplete*.

We say that a meaning derivation for an utterance is *semantically coherent* if the meaning derivation produces a meaning for the utterance with no additional unused premises remaining. If extra resources besides the semantic resource for the utterance remain, the utterance is *semantically incoherent*.

Semantic completeness and coherence are related in a clear way to the syntactic Completeness and Coherence conditions on f-structures discussed in Chapter 2, Section 3.6. This is as expected, since most syntactic arguments also make a semantic contribution and thus must be accounted for in a meaning derivation; indeed, our logically defined semantic completeness and coherence conditions subsume syntactic Completeness and Coherence in all cases except for pleonastic or semantically empty arguments, which make no semantic contribution and are not accounted for in a semantic derivation. The following sentence is syntactically and semantically incomplete:

(52) **Yawned*.

The sentence is syntactically incomplete because the verb *yawned* requires a SUBJ, and no subject is present; the sentence is semantically incomplete because the meaning constructor for *yawned* requires a semantic resource corresponding to its subject, but none can be found. Example (53) is both syntactically and semantically incoherent:

(53) **David yawned Chris*.

This example is syntactically incoherent due to the presence of an OBJ argument, which *yawned* does not require. It is semantically incoherent because the meaning constructor for *yawned* requires only a SUBJ resource, and in a meaning deduction for these premises the semantic resource for *Chris* remains unused.

Semantic and syntactic completeness differ for arguments that make no semantic contribution:

(54) **Rained*.

The verb *rained* requires a SUBJ, but there is no SUBJ in example (54); therefore, the sentence is syntactically incomplete. The semantic completeness condition is not violated, however, because the SUBJ of *rained* is not required to make a semantic contribution.

Another difference between syntactic and semantic coherence involves modifying adjuncts: a semantic deduction in which the meaning contribution of a

modifier is not incorporated is semantically incoherent, since all meanings must be taken into account. That is, the semantic coherence condition prevents us from assigning an unmodified meaning to a sentence with a modifier:

(55) *David ran quickly*.

cannot mean: $run(David)$

The modifier *quickly* is not constrained by the syntactic Completeness and Coherence conditions, which apply only to governable grammatical functions. Semantically, however, its meaning contribution must be taken into account, and the deduction is semantically incoherent if the modifier meaning does not appear.

7.2. Glue Deductions and Meaning

Glue semantic deductions have an interesting property: as shown by Dalrymple et al. (1999a), whether or not a glue deduction is possible depends only on the linear logic glue formulas on the right-hand side of the meaning constructor, never on the meanings involved in the deduction. This means that we can think of the meaning deduction process purely in terms of the linear logic deduction over semantic structures; on the basis of the resulting deduction, we can determine the meaning of the resulting constituents by function abstraction and application.

For example, we can present deductions in an abbreviated form like (56), which is the same as the deduction in (37) of this chapter except that meaning terms have been omitted. On the basis of this deduction, we can determine the meaning corresponding to the semantic structure y_σ by function application, following the function application rule presented in (35) of this chapter.

(56)

d_σ	The SUBJ semantic structure d_σ is present.
$d_\sigma \multimap y_\sigma$	If we find a resource for the SUBJ semantic structure d_σ, we can produce a resource for the semantic structure for the full sentence y_σ.
y_σ	We have produced a semantic structure for the full sentence y_σ.

In fact, as discussed by Dalrymple et al. (1999a), this aspect of glue semantic deductions is strongly similar to Categorial Grammar (Oehrle et al. 1988; Moortgat 1988, 1996; Morrill 1994; Steedman 1996). Linguistic analysis in Categorial Grammar is a deductive process, in which the syntactic structure and the meaning of a sentence are obtained by a logical deduction from premises contributed by its words. The Lambek calculus (Lambek 1958), the logical system commonly used in syntactic analysis in categorial frameworks, is actually a fragment of *noncommutative multiplicative linear logic* and so is very close to the linear logic glue language.

Probably the most important difference between the categorial approach and the glue approach is in the syntactic primitives that are relevant for semantic composition. In categorial grammar, a predicate combines with its arguments on the basis of relations defined on the surface string, like to-the-left-of and to-the-right-of; in the glue approach, in contrast, semantic deductions are guided by f-structural relations like SUBJ, COMP, and ADJ. This frees the glue approach from concerns with crosslinguistically variable constituent structure relations and allows semantic composition to proceed according to the more abstract syntactic organization of f-structure.

8. QUANTIFICATION

Here we will briefly outline our theory of quantification and the treatment of generalized quantifiers, since an explicit theory of the syntax and semantics of noun phrases will be important in subsequent discussion, particularly in our discussion of adjectival modification and relative clauses. For a full explication of the theory of quantification presented in this section, see Dalrymple et al. (1997b).

8.1. Quantifier Scope

As discussed in Section 4.1.4 of this chapter, the meaning of a sentence like *Everyone yawned* is:

(57) *Everyone yawned.*

$\textit{every}(X, \textit{person}(X), \textit{yawn}(X))$

Here, *every* relates an arbitrary individual represented by X to two propositions about that individual, $\textit{person}(X)$ and $\textit{yawn}(X)$. We propose the lexical entry in (58) for the quantifier *everyone*:

(58) *everyone* N $(\uparrow \text{PRED}) = \text{‘EVERYONE’}$
$\lambda S.\textit{every}(X, \textit{person}(X), S(X)) : \forall H.[\uparrow_\sigma \multimap H] \multimap H$

This entry has a number of new features, which we will explain in the following sections.

8.1.1. Quantifier Scope and Meaning Assembly

The glue side of the meaning constructor in the second line of the lexical entry in (58) has several new aspects, different from the meaning constructors for proper names and verbs that we have examined thus far:

(59) $\forall H.[\uparrow_\sigma \multimap H] \multimap H$

First, a universal quantifier $\forall$ binds the variable H, which ranges over semantic structures that correspond to possible scopes of the quantifier. The universal quantifier $\forall$ means something close to the English word *all* or *every*, and it binds the variable that follows it; see Partee et al. (1993, Chapter 7) for a full explanation. In (59), the expression $[\uparrow_\sigma \multimap H] \multimap H$ is asserted to be true for any H: if we find a resource for any H that satisfies the implication $\uparrow_\sigma \multimap H$, we can obtain the resource H.

The second new aspect of the meaning constructor in (58) is that it contains an *embedded implication*: the implication $\uparrow_\sigma \multimap H$ appears on the left side of the main linear implication operator. We can think of the expression $\uparrow_\sigma \multimap H$ as the *argument* required by the meaning constructor for *everyone*. As we have seen, the arguments required by a meaning constructor appear on the left side of the main implication operator. An intransitive verb like *yawned* requires as its argument the meaning of its subject, $(\uparrow \text{SUBJ})_\sigma$:

(60) $\lambda Y.\textit{yawn}(Y) : (\uparrow \text{SUBJ})_\sigma \multimap \uparrow_\sigma$

In contrast, the quantifier *every* takes a more complex argument, an implicational meaning constructor $\uparrow_\sigma \multimap H$, in the lexical entry in (58). That is, *every* requires as its argument a meaning constructor that consumes a resource for $\uparrow_\sigma$ to produce some semantic structure H. An intransitive verb with the quantifier *everyone* as its subject would provide such a meaning, since it consumes a meaning for $\uparrow_\sigma$, the semantic structure for *everyone*, to produce another semantic resource which we can call H. Any other meaning constructor that consumes a meaning for $\uparrow_\sigma$ to produce another semantic structure H will also fill the bill.

As Saraswat (1999) notes, another way to think of the embedded implication in (58) is that the quantifier must perform a test on its environment to determine whether some implicational resource can be found which matches the required resource $\uparrow_\sigma \multimap H$. To perform this test, the quantifier proposes the resource $\uparrow_\sigma$, just as the abstraction rule given in (36) of this chapter allows a hypothetical resource to be proposed in order to create a function. If a resource H can then be obtained for some semantic structure H, the requirements of the quantifier are satisfied, and the conclusion H is valid.

8.1.2. Quantifier Scope Meaning

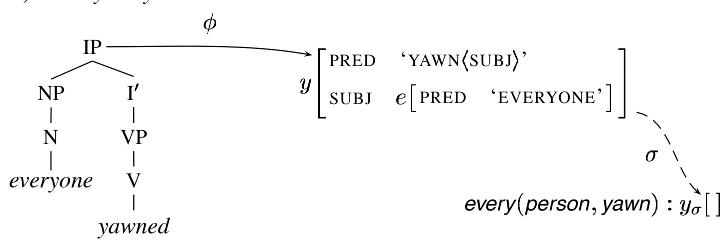
The meaning (left-hand) side of the lexical entry for *everyone* in (58) is:

(61) $\lambda S.\mathit{every}(X, \mathit{person}(X), S(X))$

In this expression, the expression $S(X)$ represents possible meanings for the scope of the quantifier.

To take a concrete example, we begin with the c-structure, f-structure, and meaning constructors for the sentence *Everyone yawned*, displayed in (62):

(62) *Everyone yawned*.



[everyone]	$\lambda S.\mathit{every}(X, \mathit{person}(X), S(X)) \;:\; \forall H.[e_\sigma \multimap H] \multimap H$
[yawn]	$\lambda Y.\mathit{yawn}(Y) \;:\; e_\sigma \multimap y_\sigma$

The right-hand side of the meaning constructor labeled **[everyone]** requires as its argument a meaning constructor of the form in (63):

(63) $e_\sigma \multimap H$

The glue side of the meaning constructor labeled **[yawn]** is of just this form, and the derivation is successful if the variable H for the scope semantic structure is instantiated to y_σ. Following the discussion in Section 7.2 of this chapter, we perform the glue deduction shown in example (66) (page 248), displaying only the glue sides of the meaning constructors. To determine the meaning that results from combining the meaning constructors labeled **[everyone]** and **[yawn]** according to the glue deduction in (66), we follow the function application rule presented in (35) of this chapter, applying the meaning of the quantifier $\lambda S.\mathit{every}(X, \mathit{person}(X), S(X))$ to its argument $\lambda Y.\mathit{yawn}(Y)$. The resulting meaning expression is:

(64) $\mathit{every}(X, \mathit{person}(X), [\lambda Y.\mathit{yawn}(Y)](X))$

or, equivalently:

(65) $\mathit{every}(X, \mathit{person}(X), \mathit{yawn}(X))$

(66) $\forall H.[e_\sigma \multimap H] \multimap H$ — If we are given a resource $e_\sigma \multimap H$ for some semantic structure H, we can produce a resource for H.

$e_\sigma \multimap y_\sigma$ — If we are given a resource e_σ corresponding to the SUBJ, we can produce a resource y_σ for the entire sentence.

---

y_σ — We have produced a resource y_σ for the full sentence.

In sum, assuming the meaning constructors shown in (62) for *everyone* and *yawned*, we can perform the following full glue deduction:

(67) $\lambda S.\mathit{every}(X, \mathit{person}(X), S(X)) : \forall H.[e_\sigma \multimap H] \multimap H$

On the glue side, if we are given a resource $e_\sigma \multimap H$ for some semantic structure H, we can produce a resource for H. On the meaning side, we apply the predicate $\lambda S.\mathit{every}(X, \mathit{person}(X), S(X))$ to the meaning corresponding to the resource $e_\sigma \multimap H$.

$\lambda Y.\mathit{yawn}(Y) : e_\sigma \multimap y_\sigma$

If we are given a resource e_σ corresponding to the SUBJ, we can produce a resource y_σ for the entire sentence. The meaning corresponding to this expression is $\lambda Y.\mathit{yawn}(Y)$.

$\mathit{every}(X, \mathit{person}(X), \mathit{yawn}(X)) : y_\sigma$

We have produced a resource y_σ for the full sentence, corresponding to the meaning $\mathit{every}(X, \mathit{person}(X), \mathit{yawn}(X))$, by assuming that H is the semantic structure y_σ.

We conclude that the sentence has the meaning $\mathit{every}(X, \mathit{person}(X), \mathit{yawn}(X))$, as desired.

8.1.3. Determination of Scope Semantic Structure

Example (67) shows that the variable H in the semantic constructor for the quantifier *everyone* can be instantiated to the semantic structure y_σ. In Section 4.1.4 of this chapter, we saw that the scope of a quantifier is not syntactically fixed: sentences with quantifiers may exhibit quantifier scope ambiguity. What are the possible semantic structures that can be chosen as the scope of a quantifier?

First, we note that the semantic structure that is chosen as the scope of a quantifier need not correspond to any f-structure constituent. For example, it has long been noted that the restriction of a quantifier can serve as the scope of another quantifier (Dalrymple et al. 1997b):

(68) *Every relative of a student attended.*

One reading of this sentence is:

(69) $\textit{every}(X, \textit{a}(Y, \textit{student}(Y), \textit{relative-of}(X, Y)), \textit{attend}(X))$

An abbreviated f-structure for this sentence is:

(70) *Every relative of a student attended.*

$$\begin{bmatrix} \text{PRED} & \text{`ATTEND}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{SPEC} & \begin{bmatrix}\text{PRED} & \text{`EVERY'}\end{bmatrix} \\ \text{PRED} & \text{`RELATIVE}\langle\text{OBL}_{\text{OF}}\rangle\text{'} \\ \text{OBL}_{\text{OF}} & \begin{bmatrix} \text{SPEC} & \begin{bmatrix}\text{PRED} & \text{`A'}\end{bmatrix} \\ \text{PRED} & \text{`STUDENT'}\end{bmatrix}\end{bmatrix}\end{bmatrix}$$

Treating the determiner *a* as a quantifier, we see that its scope is $\textit{relative-of}(X, Y)$, the proposition that Y is a relative of X. This meaning corresponds roughly to the subphrase *relative of*, but does not correspond to an f-structure constituent. Instead, the more fine-grained semantic structure is the appropriate level to define quantifier scoping possibilities; this will become clear in our discussion of the meanings of determiners and common noun phrases in Section 8.2 of this chapter.

Second, we require the scope of the quantifier to contain the variable bound by the quantifier. That is, the scope of the quantifier must be a function of the argument position in which the quantifier appears. As noted by Dalrymple et al. (1997b), this follows without stipulation from our logical system: the embedded implication that the quantifier requires to determine its scope meaning must consume the meaning of the quantified noun phrase to produce the scope meaning.

A number of other constraints on quantifier scoping have been proposed: quantifiers may be required to find their scope inside some syntactically definable domain, or to scope either inside or outside another quantifier. Since our focus here is not on a complete theory of quantification, we will not discuss constraints like these or show how they can be incorporated into the framework we propose. For

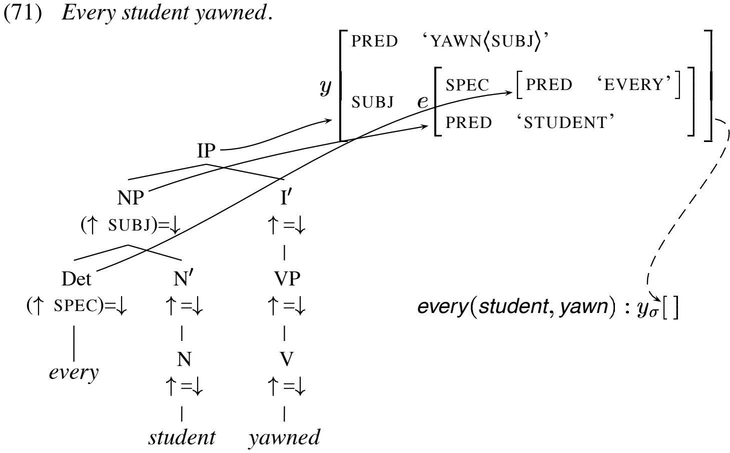
detailed discussion of quantifier scoping constraints and a proposal for how they should be imposed in a glue setting, see Crouch and van Genabith (1999).

8.2. Determiners and Nouns

We now turn to an example involving a determiner and noun, *Every student yawned*. This example illustrates how the meanings of the determiner *every* and the common noun *student* are combined. As we will see, a deduction from the meaning constructors for *every* and *student* produces a meaning similar to the one proposed in (58) of this chapter for *everyone*, which can play a similar role in meaning assembly.

The c-structure, f-structure, and semantic representation for the sentence *Every student yawned* are displayed in (71):

(71) *Every student yawned.*



We propose the lexical entry in (72) for the determiner *every*:

(72) *every* Det (↑ PRED) = 'EVERY'

$$\lambda R.\lambda S.\textit{every}(X, R(X), S(X)) :$$
$$[((\text{SPEC}\uparrow)_\sigma\ \text{VAR}) \multimap ((\text{SPEC}\uparrow)_\sigma\ \text{RESTR})] \multimap$$
$$[\forall H.[(\text{SPEC}\uparrow)_\sigma \multimap H] \multimap H]$$

The meaning constructor for *every* uses *inside-out functional uncertainty* (Chapter 6, Section 1.2) to refer to the f-structure for the noun phrase that contains it. The expression (SPEC ↑) in this entry refers to the f-structure in which *every* appears as the SPEC value, which is the f-structure labeled e in (71).

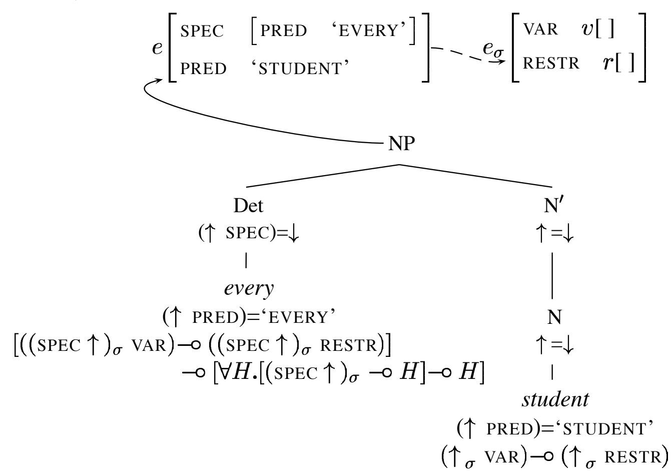
The lexical entry for the common noun *student* is given in (73):

(73) *student* N $(\uparrow \text{PRED}) = \text{`STUDENT'}$
$\lambda X.\textit{student}(X) : (\uparrow_\sigma \text{VAR}) \multimap (\uparrow_\sigma \text{RESTR})$

The lexical entries in (72) and (73) indicate that the semantic structure e_σ corresponding to the SUBJ f-structure is complex and has internal structure; it contains two attributes, VAR and RESTR, with semantic structures as their values. The attribute VAR represents a variable of type e, and the attribute RESTR represents a restriction on that variable of type t: in this case, that the variable must range over individuals that are students.

These lexical entries, together with the standard English phrase structure rules, give rise to the structures shown in (74); to save space, only the glue sides of the meaning constructors for *every* and *student* are displayed, and the meaning sides are omitted:

(74) *every student*



Instantiating the $\uparrow$ and $\downarrow$ variables and using the labels v and r for the semantic structures $(e_\sigma \text{ VAR})$ and $(e_\sigma \text{ RESTR})$, we have the meaning constructors in (75), labeled **[every]** and **[student]**:

(75) Meaning constructor premises for *every student*:

[every] $\lambda R.\lambda S.\textit{every}(X, R(X), S(X)) \ : \ [v \multimap r] \multimap [\forall H.[e_\sigma \multimap H] \multimap H]$

[student] $\lambda X.\textit{student}(X) \ : \ v \multimap r$

The meaning constructor for **[every]** requires two arguments: just as a transitive verb needs two semantic contributions, one from its subject and one from its object, a quantifier like *every* needs a semantic contribution from its restriction (the meaning of the common noun and any modifiers it might have) and its scope.

The first requirement is for a meaning for the restriction of the quantifier:

(76) $v \multimap r$

This requirement exactly matches the contribution of the common noun *student*, and the meaning of *student* becomes the restriction of the quantifier *every*.

The second requirement for the quantifier *every* is a meaning for its scope:

(77) $e_\sigma \multimap H$

As described in Section 8.1 of this chapter for the quantifier *everyone*, the quantifier requires a contribution of the form $e_\sigma \multimap H$, whose meaning corresponds to the scope meaning S of *every*.

We can now deduce the meaning constructor for *every student* from the meaning constructors for *every* and for *student*:

(78) Combining the meanings of *every* and *student*:

$\lambda R.\lambda S.\textit{every}(X, R(X), S(X)) : [v \multimap r] \multimap [\forall H.[e_\sigma \multimap H] \multimap H]$

The meaning constructor for *every* requires a resource $v \multimap r$ corresponding to its restriction meaning R, and a resource $e_\sigma \multimap H$ corresponding to its scope meaning S, to produce a resource H for its scope semantic structure.

$\lambda X.\textit{student}(X) : v \multimap r$

The meaning constructor for *student* provides an implicational resource $v \multimap r$ corresponding to the meaning $\lambda X.\textit{student}(X)$.

$\lambda S.\textit{every}(X, \textit{student}(X), S(X)) : \forall H.[e_\sigma \multimap H] \multimap H$

Therefore, by combining the meanings of *every* and *student*, we get a result that is like the meaning constructor for *everyone*, except that the restriction of the quantifier *every* is specified to involve students.

The resulting meaning constructor for *every student* is, as desired, of the same rough shape as the meaning for *everyone*, since in terms of meaning construction, they behave alike; only the meanings associated with the semantic structures differ.

Completing the deduction, we have the meaning *every*(*student*, *yawn*) for this sentence, which is the desired result:

(79) *Every student yawned.*

$$y\begin{bmatrix} \text{PRED} & \text{'YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & e\begin{bmatrix} \text{SPEC} & \begin{bmatrix}\text{PRED} & \text{'EVERY'}\end{bmatrix} \\ \text{PRED} & \text{'STUDENT'} \end{bmatrix} \end{bmatrix}$$

[every] $\lambda R.\lambda S.\mathit{every}(X, R(X), S(X))$:
$[(e_\sigma \text{ VAR}) \multimap (e_\sigma \text{ RESTR})] \multimap [\forall H.[e_\sigma \multimap H] \multimap H]$

[student] $\lambda X.\mathit{student}(X) : (e_\sigma \text{ VAR}) \multimap (e_\sigma \text{ RESTR})$

[yawn] $\lambda X.\mathit{yawn}(X) : e_\sigma \multimap y_\sigma$

[every], [student], [yawn] $\vdash \mathit{every}(X, \mathit{student}(X), \mathit{yawn}(X)) : y_\sigma$

With this basis in the theory of meaning assembly, we are now ready to begin an exploration of the syntax and semantics of a variety of linguistic constructions. In the next five chapters, we will discuss the syntax and semantics of modification (Chapter 10); syntactic constraints on the anaphor-antecedent relation and the semantics of binding (Chapter 11); the syntax and semantics of functional and anaphoric control in constructions with raising and equi verbs (Chapter 12); the syntax of constituent and nonconstituent coordination, resource sharing at the syntax-semantics interface, and the syntax and semantics of noun phrase coordination (Chapter 13); and the syntax of long-distance dependencies and the semantics of relative clauses and wh-questions (Chapter 14).

9. FURTHER READING AND RELATED ISSUES

This chapter has been devoted to an exploration of linguistic meaning and the syntax-semantics interface. The intention has been to give the reader the linguistic intuitions behind the analyses, and we have not emphasized the formal and mathematical properties of the glue language, linear logic. The presentation of analyses in subsequent chapters is also aimed primarily at an intuitive understanding of how meaning deductions work. It is important to keep in mind, however, that despite the informal nature of the presentation here and in the following chapters, our theory of meaning composition is grounded in a mathematically precise, rigorously defined logic. We will not give a more technically oriented introduction or overview discussion of linear logic in this volume, since such material is readily available from other sources. Dalrymple et al. (1999b) give a more detailed

introduction to linear logic in the current setting (see also Dalrymple et al. 1995e). For the logically inclined, the appendix presents the proof rules for our fragment of linear logic. Linear logic originated in the work of Girard (1987); a very accessible general overview is given by Scedrov (1993), and Crouch and van Genabith (2000) provide an in-depth treatment with a linguistic orientation.

We will also omit discussion of proof methods or algorithms for deduction in linear logic; again, this material is widely available for consultation by those interested in formal and computational aspects of glue theory. Girard (1987) introduced the notion of *proof nets* for proofs in the fragment of linear logic we use; for a lucid description of the use of proof nets for deduction in the glue approach, see Fry (1999a). Efficient proof techniques for glue semantic deductions are also explored by Lamping and Gupta (1998).

Besides the work mentioned in this chapter, there are a number of papers on linguistic issues relating to glue theory. The papers in Dalrymple (1999) provide an overview of the theory as well as discussions of formal aspects of the theory and particular linguistic phenomena. Included are treatments of quantifier scoping constraints (Crouch and van Genabith 1999), intensionality and quantifier scope (Dalrymple et al. 1997b), negative polarity (Fry 1999a), and dynamic and underspecified semantics (van Genabith and Crouch 1999a). Additional work within the glue framework includes work on ellipsis (Crouch 1999), translation within the semantic framework of Underspecified Discourse Representation Theory (Crouch et al. 2001), event semantics (Fry 1999b), and the German split NP construction (Kuhn 2001b).

10

MODIFICATION

This chapter explores issues in the syntax and semantics of modification. Since there is in principle no limit to the number of modifiers that a phrase can have, we represent modifiers at functional structure as members of a set of modifying adjuncts ADJ (Chapter 2, Section 3.4). Functional annotations on c-structure rules ensure that each modifier appears as a member of the adjunct set associated with the phrase it modifies.

In the following, we will concentrate in particular on adjectival modification, since the syntax and semantics of adjectives is fairly complex and illustrates many of the issues of interest to us. Section 1 of this chapter provides an overview of the syntax of adjectival modification, Section 2 discusses three semantic classes of adjectives and how their meanings are represented, and Section 3 discusses adjectival modification at the syntax-semantics interface within the glue approach.

Defining the semantic contribution of a modifier brings up a set of tricky problems, as first noticed by Kasper (1995). In Section 4, we will address these issues and show that they have a straightforward solution within our framework.

The chapter concludes with a brief examination of the syntax and semantics of adverbial modification: Section 5 discusses the syntax and semantics of manner adverbials like *skillfully* as well as sentential adverbs like *necessarily*.

1. SYNTAX OF ADJECTIVAL MODIFICATION

1.1. Modification at Functional Structure

As discussed in Chapter 2, Section 1.2, modifiers are different from arguments in that they can be multiply specificational:

(1) a. *The girl handed the baby a toy $\underline{\textit{on Tuesday}}$ $\underline{\textit{in the morning}}$.*
b. **David saw $\underline{\textit{Tony}}$ $\underline{\textit{Mr. Gilroy}}$ $\underline{\textit{my next-door neighbor}}$.*

At f-structure, each modifier is a member of the set of modifiers of a phrase. In example (2), the adjectival modifier *Swedish* is treated as a member of the modifying adjunct set ADJ of modifiers of the noun *man*:

(2) *Swedish man*

$$\begin{bmatrix} \text{PRED} & \text{`MAN'} \\ \text{ADJ} & \left\{ \begin{bmatrix} \text{PRED} & \text{`SWEDISH'} \end{bmatrix} \right\} \end{bmatrix}$$

In phrases with more than one modifier, the f-structure for each modifier appears as a member of the ADJ set:

(3) *tall Swedish man*

$$\begin{bmatrix} \text{PRED} & \text{`MAN'} \\ \text{ADJ} & \left\{ \begin{matrix} \begin{bmatrix} \text{PRED} & \text{`TALL'} \end{bmatrix} \\ \\ \begin{bmatrix} \text{PRED} & \text{`SWEDISH'} \end{bmatrix} \end{matrix} \right\} \end{bmatrix}$$

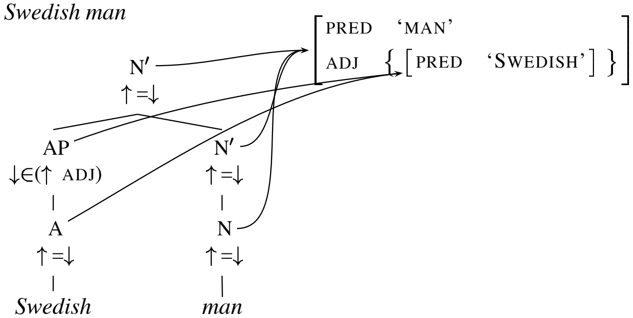
The lexical entries for *tall*, *Swedish*, and *man* contain at least the following syntactic information:

(4)
tall	A	$(\uparrow \text{PRED}) = \text{`TALL'}$
Swedish	A	$(\uparrow \text{PRED}) = \text{`SWEDISH'}$
man	N	$(\uparrow \text{PRED}) = \text{`MAN'}$

1.2. Constituent Structure Constraints

At constituent structure, modifiers are often adjoined to the phrases they modify (Chapter 3, Section 4.2). The c-structure and f-structure for the English noun phrase *Swedish man* is shown in (5), with the modifier *Swedish* adjoined at the N′ level:

(5) *Swedish man*

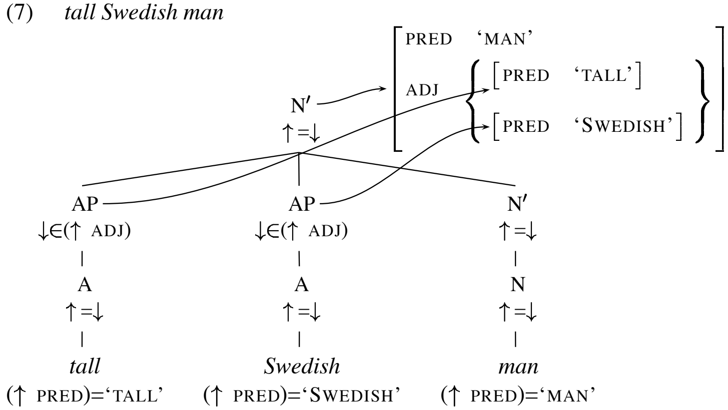


We propose the following adjunction rule for adjective phrase modifiers in English:

(6) $\mathrm{N}' \longrightarrow \underset{\downarrow \in (\uparrow \text{ ADJ})}{\mathrm{AP}^*} \quad \left(\begin{matrix}\mathrm{N}' \\ \uparrow = \downarrow\end{matrix}\right)$

This rule, which supplements the rule in which N′ dominates only its head N and any arguments of N, allows for any number of adjectives to be adjoined at the N′ level. At f-structure, each modifying adjective is a member of the modifying adjunct set ADJ. In example (7), two adjectives have been adjoined:

(7) *tall Swedish man*



2. SEMANTIC CLASSES OF ADJECTIVES

Influential work on the semantics of adjectives was done by Montague (1974a) and Kamp (1975), who focused primarily on the three types of adjectives to be examined in this section. Their basic view of the semantics of adjectival modification has been widely adopted.

As discussed in Chapter 9, Section 8.2, the meaning of the proper noun *man* is:

(8) *man*

$\lambda X.\mathit{man}(X)$

This meaning is of type $\langle e \to t \rangle$. It picks out the set of men — that is, the set of entities X for whom the proposition $\mathit{man}(X)$ is true. When a meaning like the one in (8) is modified, the result is a meaning which is of the same type but which reflects a modified meaning rather than the original unmodified meaning. In the following, we describe how noun meanings are modified in different ways by different semantic classes of adjectives.

The meaning of *Swedish man* can be represented as in (9), in which the conjunction operator $\wedge$ conjoins the two expressions $\mathit{Swedish}(X)$ and $\mathit{man}(X)$:

(9) *Swedish man*

$\lambda X.\mathit{Swedish}(X) \wedge \mathit{man}(X)$

The type of this meaning is $\langle e \to t \rangle$, just like the unmodified meaning *man*; the difference in meaning is that this expression picks out the set of individuals X that satisfy both the predicate $\mathit{Swedish}(X)$ and the predicate $\mathit{man}(X)$ — the individuals that are both Swedish and men. Adjectives like *Swedish* are called *intersective*, since the individuals that are Swedish men are those that are in the intersection of the set of individuals that are Swedish with the set of individuals that are men.

Adjectives like *big* or *tall* are called *gradable adjectives*. As noted by Montague (1974a), Kamp (1975), Siegel (1976), Kennedy (1997), and many others, gradable adjectives like *big* or *tall* must be interpreted relative to some relevant standard. For example, some individual mouse might count as a *big mouse*, even though the same mouse is probably not a big animal or even a big rodent. Similarly, a second-grade boy can be correctly characterized as a *tall second-grader* even if he is not tall compared to an adult.

We propose the following simplified meaning for *big mouse* (see Kennedy 1997 for a full discussion of the semantics of gradability and comparison):

(10) *big mouse*

$\lambda X.\mathit{big}(X, \mathcal{P}) \wedge \mathit{mouse}(X)$

The argument $\mathcal{P}$ of *big* represents the property that determines the relevant standard of measurement; as Kennedy (1997) shows, the standard according to which gradable adjectives are interpreted is determined by some contextually salient property of the individual. If the contextually salient property $\mathcal{P}$ of the individual is that it is a mouse, modification by the adjective *big* requires the individual to exceed some standard of size that is determined by reference to mousehood. In other words, if something is big relative to the property of being a mouse, we need to know the range of sizes that are appropriate for mice, and we need to know that this individual is bigger than a standard-size mouse.

In a neutral context, the contextually relevant property is often the property denoted by the modified noun; for example, the contextually salient property $\mathcal{P}$ in an example like *big mouse* is generally resolved to the property of being a mouse. However, as pointed out by McConnell-Ginet (1979) and Pollard and Sag (1994), in certain contexts other interpretations are also possible. Pollard and Sag provide the following example:

(11) *The Linguistics Department has an important volleyball game coming up against the Philosophy Department. I see the Phils have recruited Julius to play with them, which means we are in real trouble unless we can find a good linguist to add to our team in time for the game.*

Here the property $\mathcal{P}$ relevant to the interpretation of the adjective *good* is being a volleyball player, since in this example *good linguist* means, more or less, *linguist that is good at playing volleyball*. Examples such as these show that the property $\mathcal{P}$ need not correspond to the property denoted by the modified noun, but is determined contextually.

Of course, modified phrases can undergo further modification. The meaning of the doubly modified phrase *tall Swedish man* is:

(12) *tall Swedish man*

$$\lambda X.\mathit{tall}(X, \mathcal{P}) \wedge \mathit{Swedish}(X) \wedge \mathit{man}(X)$$

Even in a neutral context, the contextually relevant property $\mathcal{P}$ involved in the interpretation of the adjective *tall* can be resolved in several ways. It can refer to someone who is Swedish, a man, and tall for a man, in which case the contextually relevant property $\mathcal{P}$ is the property of being a man. It can also refer to someone who is Swedish, a man, and tall for a Swedish man, in which case the contextually relevant property $\mathcal{P}$ is the property of being a Swedish man.

Another class of modifying adjectives, studied by Kamp (1975) and in more detail by Siegel (1976), is the class of *intensional adjectives* such as *imaginary*, *former*, *fake*, and *alleged*. These adjectives are different from those discussed in the previous section in an important way: a *Swedish man* is a man, and a *big mouse* is a mouse, but a *fake gun* is not a gun; instead, it may actually be a toy or a piece of soap. Thus, the meaning of a phrase with an intensional adjective

depends on the meaning of the unmodified phrase, but the resulting property may hold of an individual even if the unmodified meaning does not.

Like other adjectives, an intensional adjective operates on the description it modifies and produces a new description of the same type:

(13) *former senator*

$$\lambda X.\mathit{former}(\mathit{senator}, X)$$

A former senator is one who at some previous time was a senator, but who is no longer a senator; the meaning of *senator* is important in understanding the meaning of *former senator*, but the individuals represented by X in the meaning given in (13) for *former senator* are not required to be senators. Thus, *former* in (13) denotes a relation between the property of being a senator and some individual who formerly had that property. Similarly, a fake gun is an entity that is not a gun, but which has some properties in common (for example, appearance) with entities that are actually guns; again, although a fake gun is not a gun, the meaning of *gun* is important in determining the meaning of *fake gun*:

(14) *fake gun*

$$\lambda X.\mathit{fake}(\mathit{gun}, X)$$

Importantly, the resulting meaning still has type $\langle e \rightarrow t \rangle$; intensional adjectives, like intersective adjectives and gradable adjectives, turn an unmodified $\langle e \rightarrow t \rangle$ meaning into a modified $\langle e \rightarrow t \rangle$ meaning. This characteristic is shared by all modifiers and will be important in our analysis of modification and meaning composition.

3. MODIFIERS AND SEMANTIC COMPOSITION

As Montague (1974a) and Kamp (1975) point out, adjectival modifiers are functions that take a property of type $\langle e \rightarrow t \rangle$ (such as the property of being a man) and produce a new property (such as the property of being a Swedish man). This intuition is reflected in the glue semantic premises contributed by modifiers.

3.1. Adjectival Modification

As shown in Chapter 9, Section 8.2, a common noun like *man* is associated with the syntactic and semantic structures and meaning constructor given in (15), where the semantic structures v and r are the values of the attributes VAR and RESTR in the semantic structure f_σ:

(15) *man*

$$f\begin{bmatrix}\text{PRED} & \text{`MAN'}\end{bmatrix} \dashrightarrow f_\sigma\begin{bmatrix}\text{VAR} & v[\ ]\\ \text{RESTR} & r[\ ]\end{bmatrix}$$

$$\lambda X.\textit{man}(X) : v \multimap r$$

A modified noun like *Swedish man* is associated with a meaning constructor whose right-hand side is exactly the same as the meaning constructor for *man*, but whose left-hand side is associated with a modified meaning rather than an unmodified one:

(16) *Swedish man*

$$f\begin{bmatrix}\text{PRED} & \text{`MAN'}\\ \text{ADJ} & \left\{\begin{bmatrix}\text{PRED} & \text{`SWEDISH'}\end{bmatrix}\right\}\end{bmatrix} \dashrightarrow f_\sigma\begin{bmatrix}\text{VAR} & v[\ ]\\ \text{RESTR} & r[\ ]\end{bmatrix}$$

$$\lambda X.\textit{Swedish}(X) \wedge \textit{man}(X) : v \multimap r$$

In this section, we show how a meaning constructor like the one in (16) is derived from the meaning constructors for *Swedish* and *man*.

The lexical entries for *Swedish* and *man*, augmented with meaning constructors, are given in (17):

(17) *man* $(\uparrow \text{PRED}) = \text{`MAN'}$
$\lambda X.\textit{man}(X) : (\uparrow_\sigma \text{VAR}) \multimap (\uparrow_\sigma \text{RESTR})$

Swedish $(\uparrow \text{PRED}) = \text{`SWEDISH'}$
$\lambda P.\lambda X.\textit{Swedish}(X) \wedge P(X)$:
$[((\text{ADJ} \in \uparrow)_\sigma \text{VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma \text{RESTR})] \multimap$
$[((\text{ADJ} \in \uparrow)_\sigma \text{VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma \text{RESTR})]$

The meaning constructor for *man* is familiar from our discussion of common nouns in Chapter 9, Section 8.2. The meaning constructor for *Swedish* uses *inside-out functional uncertainty* (Chapter 6, Section 1.2) to refer to the semantic structure of the phrase it modifies. The expression $(\text{ADJ} \in \uparrow)$ refers to the f-structure in which $\uparrow$ appears as a member of the modifier set,[1] the expression $(\text{ADJ} \in \uparrow)_\sigma$ refers to the semantic structure corresponding to that f-structure, and the expression $((\text{ADJ} \in \uparrow)_\sigma \text{VAR})$ refers to the value of the attribute VAR in that semantic structure, labeled v in (16) above. Similarly, the expression $((\text{ADJ} \in \uparrow)_\sigma \text{RESTR})$ refers to the value of the RESTR attribute, labeled r.

Instantiating the meaning constructors in (17) according to the labels on the structures displayed in (16), we have the following instantiated meaning constructors for *Swedish* and *man*:

[1] The use of the set membership symbol $\in$ as an attribute is discussed in Chapter 6, Section 2.1.

(18) Meaning constructor premises for *Swedish man*:

[man]	$\lambda X.\textit{man}(X) : v \multimap r$
[Swedish]	$\lambda P.\lambda X.\textit{Swedish}(X) \wedge P(X) : [v \multimap r] \multimap [v \multimap r]$

The right-hand side of the meaning constructor for *Swedish* illustrates the characteristic glue contribution of a modifier: it requires a resource of the form $v \multimap r$ as its argument and produces a resource of exactly the same form. The general form for modifiers is given in (19), where $\mathcal{M}$ is the meaning of the modifier and S is the glue contribution of the phrase it modifies:

(19) $\mathcal{M} : S \multimap S$

Modifiers consume a meaning resource S and produce an identical new meaning resource S for the phrases they modify.

Given the premises **[Swedish]** and **[man]**, we can perform a deduction that produces the meaning constructor for *Swedish man* given in (16).

(20) $\lambda X.\textit{man}(X) : v \multimap r$

The meaning $\lambda X.\textit{man}(X)$ is associated with the implicational contribution $v \multimap r$.

$\lambda P.\textit{Swedish}(X) \wedge P(X) : [v \multimap r] \multimap [v \multimap r]$

On the glue side, the meaning constructor consumes the noun contribution $v \multimap r$ and produces a new modified meaning which is also associated with $v \multimap r$. On the meaning side, we apply the function $\lambda P.\textit{Swedish}(X) \wedge P(X)$ to the unmodified meaning contributed by *man*, $\lambda X.\textit{man}(X)$.

$\lambda X.\textit{Swedish}(X) \wedge \textit{man}(X) : v \multimap r$

We have produced a modified meaning $\lambda X.\textit{Swedish}(X) \wedge \textit{man}(X)$ associated with the implicational contribution $v \multimap r$.

We can also represent this deduction in abbreviated form, as shown in Chapter 9, using the labels in (18):

(21) **[Swedish], [man]** $\vdash \lambda X.\textit{Swedish}(X) \wedge \textit{man}(X) : v \multimap r$

3.2. Gradable Adjectives

Gradable adjectives like *big* differ from intersective adjectives like *Swedish* in introducing a contextually salient property $\mathcal{P}$ in their interpretation:

(22) *big mouse*

$$f\begin{bmatrix}\text{PRED} & \text{`MOUSE'} \\ \text{ADJ} & \left\{ \begin{bmatrix}\text{PRED} & \text{`BIG'}\end{bmatrix} \right\}\end{bmatrix} \rightsquigarrow f_\sigma \begin{bmatrix}\text{VAR} & v[\;] \\ \text{RESTR} & r[\;]\end{bmatrix}$$

$$\lambda X.\mathit{big}(X,\mathcal{P}) \wedge \mathit{mouse}(X) : v \multimap r$$

The meaning contribution of *big mouse* given in (22) refers to a mouse that exceeds the size of individuals that are described by the contextually determined property $\mathcal{P}$. Since the property $\mathcal{P}$ is determined by contextual factors, not syntactically, we will not specify a means for determining $\mathcal{P}$ but instead will leave it uninstantiated.

Although the meaning contribution of a gradable adjective like *big* is not the same as that of an intersective adjective like *Swedish*, the right-hand sides of the two meaning constructors are the same, since the two kinds of adjective play a similar role in meaning assembly. The lexical entry for *big* is given in (23):

(23) *big* $(\uparrow \text{PRED}) = \text{`BIG'}$

$$\lambda R.\lambda X.\mathit{big}(X,\mathcal{P}) \wedge R(X):$$
$$[((\text{ADJ} \in \uparrow)_\sigma \text{ VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma \text{ RESTR})] \multimap$$
$$[((\text{ADJ} \in \uparrow)_\sigma \text{ VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma \text{ RESTR})]$$

Like the entry for *Swedish* given in (17) earlier, this entry uses inside-out functional uncertainty to refer to the f-structure of the phrase it modifies. The lexical entry for *mouse* is exactly analogous to the one for *man* and will not be displayed.

Instantiating the lexical entries for *big* and *mouse* according to the labels in (22), we have the instantiated meaning constructors in (24):

(24) Meaning constructor premises for *big mouse*:

[mouse] $\lambda X.\mathit{mouse}(X) \;:\; v \multimap r$

[big] $\lambda R.\lambda X.\mathit{big}(X,\mathcal{P}) \wedge R(X) \;:\; [v \multimap r] \multimap [v \multimap r]$

The meaning constructor for *big* requires a meaning resource of the form $v \multimap r$; *mouse* provides such a resource. The resulting meaning is obtained by applying the expression $\lambda R.\lambda X.\mathit{big}(X,\mathcal{P}) \wedge R(X)$ to its argument $\lambda X.\mathit{mouse}(X)$. The result is as desired — from the meaning constructors labeled **[big]** and **[mouse]** in (24), we derive the meaning constructor for *big mouse*:

(25) **[big], [mouse]** $\vdash \lambda X.\mathit{big}(X,\mathcal{P}) \wedge \mathit{mouse}(X) : v \multimap r$

3.3. Intensional Adjective Modification

The syntactic and semantic structures and meaning constructor for the phrase *former senator* are as shown in (26):

(26) *former senator*

$$f\begin{bmatrix}\text{PRED} & \text{`SENATOR'} \\ \text{ADJ} & \left\{ \begin{bmatrix}\text{PRED} & \text{`FORMER'}\end{bmatrix} \right\}\end{bmatrix} \rightsquigarrow f_\sigma \begin{bmatrix}\text{VAR} & v[\;] \\ \text{RESTR} & r[\;]\end{bmatrix}$$

$$\lambda X.\mathit{former}(\mathit{senator}, X) : v \multimap r$$

The lexical entry of *former* is given in (27):

(27) *former* $(\uparrow \text{PRED}) = \text{`FORMER'}$

$$\lambda P.\lambda X.\mathit{former}(P,X):$$
$$[((\text{ADJ} \in \uparrow)_\sigma \text{ VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma \text{ RESTR})] \multimap$$
$$[((\text{ADJ} \in \uparrow)_\sigma \text{ VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma \text{ RESTR})]$$

As shown earlier, the meaning contribution of an intensional adjective like *former* is different from *Swedish* and *big*. Nevertheless, it contributes a meaning resource of the same form: it consumes a resource corresponding to the phrase it modifies and produces a new resource of the same form. The instantiated meaning constructors for *former* and *senator* are given in (28):

(28) Meaning constructor premises for *former senator*:

[senator] $\lambda X.\mathit{senator}(X) \;:\; v \multimap r$

[former] $\lambda P.\lambda X.\mathit{former}(P,X) \;:\; [v \multimap r] \multimap [v \multimap r]$

As desired, these meaning constructors combine to produce the meaning constructor for *former senator* given in (26):

(29) **[former], [senator]** $\vdash \lambda X.\mathit{former}(\mathit{senator}, X) : v \multimap r$

Although each type of modifier makes a different kind of contribution to meaning, their roles in meaning assembly are similar; this is reflected in the meaning resources on the right-hand sides of the meaning constructors for the modifying adjectives we have examined.

4. RECURSIVE MODIFICATION

In the foregoing, we have assumed that the function of a modifier is to specify the result that is obtained when it combines with the phrase it modifies — in other words, that the meaning of an adjective is defined in terms of its effect on the element that it modifies. This common assumption is challenged in an important paper by Kasper (1995), who discusses evidence from *recursive modification*, cases in which a modifier is itself modified. In this section, we review Kasper's observations and show how they are accounted for in the glue approach.

Consider a modifier like *Swedish*, which we have assumed to have a meaning constructor like the one shown in (30):

(30) *Swedish*

$$f\left[\text{ADJ}\quad \left\{\left[\text{PRED}\quad \text{`SWEDISH'}\right]\right\}\right] \dashrightarrow f_\sigma\left[\begin{array}{ll}\text{VAR} & v[\,]\\ \text{RESTR} & r[\,]\end{array}\right]$$

$$\lambda P.\lambda X.\textit{Swedish}(X) \wedge P(X) : [v \multimap r] \multimap [v \multimap r]$$

The meaning constructor for *Swedish* given in (30) provides information about how to determine the meaning of the phrase it modifies. It does not provide a representation for the meaning of *Swedish* independent of its modifying effect; instead, it represents only the conjunctive meaning that results from combining *Swedish* with the phrase it modifies.

Kasper (1995) shows that this view is inadequate by considering examples like (31):

(31) *apparently Swedish*

$$f\left[\text{ADJ}\quad \left\{ g\left[\begin{array}{ll}\text{PRED} & \text{`SWEDISH'}\\ \text{ADJ} & \left\{ h\left[\text{PRED}\quad \text{`APPARENTLY'}\right]\right\}\end{array}\right]\right\}\right] \dashrightarrow f_\sigma\left[\begin{array}{ll}\text{VAR} & v[\,]\\ \text{RESTR} & r[\,]\end{array}\right]$$

$$\lambda P.\lambda X.\textit{apparently}(\textit{Swedish}(X)) \wedge P(X) : v \multimap r$$

In this example, the modifier *Swedish* is itself modified by the adverb *apparently*. The effect of modification by *apparently* is to modify the proposition that X is Swedish, $\textit{Swedish}(X)$, to produce a new proposition $\textit{apparently}(\textit{Swedish}(X))$. However, the proposition $\textit{Swedish}(X)$ is not by itself associated with the meaning of the adjective *Swedish*, and in fact there is no obvious way to disentangle the meaning $\textit{Swedish}(X)$ from the rest of the meaning contribution for *Swedish* in (30).

For a meaning like $\textit{Swedish}(X)$ to be available, we require an independent, modifiable characterization of the intrinsic meaning of *Swedish*, together with a theory of how this meaning combines with the meaning of the modified noun. Kasper (1995) provides an analysis of examples like (31) within the framework of Head-Driven Phrase Structure Grammar. Though it is stated in different formal terms, our analysis has a clear basis in Kasper's intuitions.

4.1. Meaning Constructors for Modifiers

To provide a full account of adjectival modification, we assume that the semantic structures of adjectives are internally structured, containing the attribute VAR. In (32), the f-structure f corresponds to a semantic structure f_σ with the attributes

VAR and RESTR; as shown earlier, the values of these attributes are labeled v and r. The f-structure g of the adjective *Swedish* also has an attribute VAR, whose value we have labeled gv:

(32) *Swedish*

$$f\left[\text{ADJ}\quad \left\{ g\left[\text{PRED}\quad \text{`SWEDISH'}\right]\right\}\right] \dashrightarrow f_\sigma\left[\begin{array}{ll}\text{VAR} & v[\,]\\ \text{RESTR} & r[\,]\end{array}\right]$$

$$g \dashrightarrow g_\sigma\left[\text{VAR}\quad gv[\,]\right]$$

The intrinsic meaning of the adjective *Swedish* is of type $\langle e \rightarrow t\rangle$. Since we assume that the basic types e and t are associated with semantic structures, we assign the type e to gv and the type t to g_σ.

We now refine our assumptions about the meaning contributions of modifiers: we propose that adjectives make two separate meaning contributions. The first meaning constructor for the adjective *Swedish* in the lexical entry in (33) contributes the intrinsic meaning of the modifier, while the second meaning constructor provides instructions for combining the first meaning constructor with the noun it modifies:

(33) Lexical entry for *Swedish* (final)

Swedish $(\uparrow \text{PRED}) = \text{`SWEDISH'}$

$$\lambda X.\textit{Swedish}(X) : [(\uparrow_\sigma\ \text{VAR}) \multimap \uparrow_\sigma]$$

$$\begin{array}{l}\lambda Q.\lambda P.\lambda X.Q(X) \wedge P(X) :\\ \quad [(\uparrow_\sigma\ \text{VAR}) \multimap \uparrow_\sigma] \multimap\\ \qquad [[((\text{ADJ} \in \uparrow)_\sigma\ \text{VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma\ \text{RESTR})] \multimap\\ \qquad\quad [((\text{ADJ} \in \uparrow)_\sigma\ \text{VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma\ \text{RESTR})]]\end{array}$$

Instantiating these two meaning constructors according to the labels given in (32) makes them much easier to read; we have labeled the first meaning constructor in the lexical entry in (33) **[Swedish1]** and the second **[Swedish2]**:

(34) Meaning constructor premises for *Swedish*:

$$\begin{array}{lrl}\textbf{[Swedish1]} & \lambda X.\textit{Swedish}(X) & : [gv \multimap g_\sigma]\\ \textbf{[Swedish2]} & \lambda Q.\lambda P.\lambda X.Q(X) \wedge P(X) & : [gv \multimap g_\sigma] \multimap [[v \multimap r] \multimap [v \multimap r]]\end{array}$$

Importantly, we can deduce the meaning constructor for *Swedish* given in (18) from the two meaning constructors in (34). The meaning constructor **[Swedish1]** provides the semantic resource $gv \multimap g_\sigma$ that is required by **[Swedish2]**, and the resulting meaning is obtained by function application: the meaning contribution of **[Swedish1]**, $\lambda Q.\lambda P.\lambda X.Q(X) \wedge P(X)$, is applied to the meaning contribution of **[Swedish2]**, $\lambda X.\textit{Swedish}(X)$.

(35) **[Swedish1], [Swedish2]** $\vdash$ **[Swedish]**

Therefore, the two meaning constructors **[Swedish1]** and **[Swedish2]** can play exactly the same role in meaning assembly as the simple meaning constructor **[Swedish]** discussed in Section 3.1 of this chapter. In particular, from the premises **[Swedish1]**, **[Swedish2]**, and **[man]**, we correctly derive the meaning constructor for *Swedish man* given in (20) of this chapter:

(36) **[Swedish1], [Swedish2], [man]** $\vdash$ $\lambda X.\textit{Swedish}(X) \wedge \textit{man}(X) : v \multimap r$

We treat other adjectival modifiers similarly: each adjective makes a twofold semantic contribution from which the simpler meaning constructors presented earlier can be deduced.

More generally, the example just presented illustrates that the simple and intuitive assumptions we make about meanings and how they combine often turn out to be largely correct, but in need of refinement to account for more complicated examples. In logical terms, the intuitively motivated meaning constructors often correspond to conclusions resulting from a deduction from a more refined set of basic meaning constructor premises. It is often easier to work with the simpler and more intuitive constructors; this is legitimate and theoretically sound as long as they follow as a logical consequence from the more basic premises.

4.2. Modification of Modifiers

We now demonstrate the derivation of the meaning for *apparently Swedish man*, an example in which the modifier *Swedish* is itself modified. As above, we introduce a VAR attribute with value hv in the semantic structure h_σ corresponding to *apparently*:

(37) *[[apparently Swedish] man]*

$$f_\sigma \begin{bmatrix} \text{VAR} & v[\;] \\ \text{RESTR} & r[\;] \end{bmatrix}$$

$$f \begin{bmatrix} \text{PRED} & \text{`MAN'} \\ \text{ADJ} & \left\{ g \begin{bmatrix} \text{PRED} & \text{`SWEDISH'} \\ \text{ADJ} & \left\{ h \begin{bmatrix} \text{PRED} & \text{`APPARENTLY'} \end{bmatrix} \right\} \end{bmatrix} \right\} \end{bmatrix} \qquad g_\sigma \begin{bmatrix} \text{VAR} & gv[\;] \end{bmatrix}$$

$$h_\sigma \begin{bmatrix} \text{VAR} & hv[\;] \end{bmatrix}$$

$\lambda X.\textit{apparently}(\textit{Swedish}(X)) \wedge \textit{man}(X) : v \multimap r$

The lexical entry for *apparently* is given in (38):

(38) *apparently* $(\uparrow \text{PRED}) = \text{`APPARENTLY'}$

$$\lambda P.\textit{apparently}(P) : [(\uparrow_\sigma \text{VAR}) \multimap \uparrow_\sigma]$$

$$\begin{aligned} &\lambda Q.\lambda R.\lambda X.Q(R(X)) \;: \\ &\quad [(\uparrow_\sigma \text{VAR}) \multimap \uparrow_\sigma] \multimap \\ &\qquad [[((\text{ADJ} \in \uparrow)_\sigma \text{VAR}) \multimap (\text{ADJ} \in \uparrow)_\sigma] \multimap \\ &\qquad\quad [((\text{ADJ} \in \uparrow)_\sigma \text{VAR}) \multimap (\text{ADJ} \in \uparrow)_\sigma]] \end{aligned}$$

Again, readability increases when the entries are instantiated according to the labels in (37):

(39) Meaning constructor premises for *apparently*:

[apparently1] $\lambda P.\textit{apparently}(P) \;:\; [hv \multimap h_\sigma]$

[apparently2] $\lambda Q.\lambda R.\lambda X.Q(R(X)) \;:\; [hv \multimap h_\sigma] \multimap [[gv \multimap g_\sigma] \multimap [gv \multimap g_\sigma]]$

As with the lexical entry for *Swedish* given in (33) of this chapter, the meaning contribution of *apparently* is twofold. The first meaning constructor in the lexical entry in (38), labeled **[apparently1]** in (39), specifies the intrinsic meaning of *apparently*, and the second meaning constructor **[apparently2]** indicates how this intrinsic meaning combines with the meaning of the phrase it modifies.

The two meaning constructors **[apparently1]** and **[apparently2]** combine to produce the meaning constructor labeled **[apparently]** in (40):

(40) **[apparently]** $\lambda R.\lambda X.\textit{apparently}(R(X)) : [gv \multimap g_\sigma] \multimap [gv \multimap g_\sigma]$

This meaning constructor consumes a meaning resource of the form $gv \multimap g_\sigma$, producing a new meaning resource of the same form but corresponding to a modified meaning.

We can now combine the meaning constructor **[apparently]** with the meaning constructor **[Swedish1]** in (34) to yield the meaning constructor in (41), labeled **[apparently-Swedish]**:

(41) **[apparently-Swedish]** $\lambda X.\textit{apparently}(\textit{Swedish}(X)) : [gv \multimap g_\sigma]$

Notably, the right-hand side of this meaning constructor is the same as the right-hand side of the unmodified meaning constructor **[Swedish1]** and plays the same role in meaning composition:

(42) **[Swedish1]** $\lambda X.\textit{Swedish}(X) : [gv \multimap g_\sigma]$

Next, we combine the meaning constructors **[apparently-Swedish]**, **[Swedish2]**, and **[man]** to produce the meaning constructor given in (37) above for *apparently Swedish man*, the correct result:

(43) **[apparently-Swedish], [Swedish2], [man]** $\vdash$

$$\lambda X.\textit{apparently}(\textit{Swedish}(X)) \wedge \textit{man}(X) : v \multimap r$$

Thus, our refined theory of the semantic contribution of modifiers enables the clean and intuitive treatment of modification presented in Section 3 of this chapter. However, it also allows an analysis of recursive modification, which, as Kasper (1995) shows, has proven problematic in many other approaches.

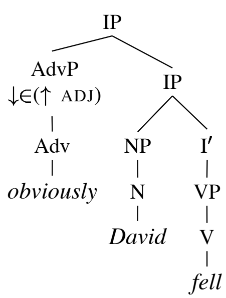
5. ADVERBIAL MODIFICATION

We now turn to an examination of the syntax and semantics of adverbial modification. The treatment provided here is brief, and we concentrate primarily on aspects of meaning composition; Butt et al. (1999, Chapter 7) provide more discussion of the syntax of adverbial modifiers from an LFG perspective.

5.1. Adverbs at C-Structure and F-Structure

In English, adverbs such as *obviously* and *skillfully* are adjoined to the phrases they modify. Like other modifiers, their f-structures appear as members of the set of ADJ modifiers. In (44), the sentential adverb *obviously* is adjoined to IP:

(44) *Obviously David fell.*

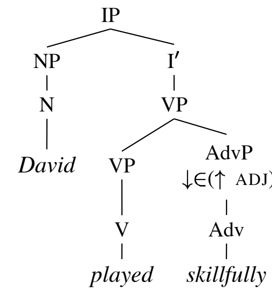


$$\begin{bmatrix} \textsc{pred} & \text{'fall}\langle\textsc{subj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{'David'} \end{bmatrix} \\ \textsc{adj} & \left\{ \begin{bmatrix} \textsc{pred} & \text{'obviously'} \end{bmatrix} \right\} \end{bmatrix}$$

A manner adverb like *skillfully* can be adjoined to VP, as in example (46) (page 270). Evidence that the adverb *skillfully* is adjoined to VP in this example comes from the VP preposing construction, discussed in Chapter 3, Section 5, where a VP appears in fronted position. If the VP includes an adverb, it is also preposed, showing that the adverb forms a constituent with the VP.

(45) *David wants to play skillfully, and [play skillfully] he will.*

(46) *David played skillfully.*



$$\begin{bmatrix} \textsc{pred} & \text{'play}\langle\textsc{subj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{'David'} \end{bmatrix} \\ \textsc{adj} & \left\{ \begin{bmatrix} \textsc{pred} & \text{'skillfully'} \end{bmatrix} \right\} \end{bmatrix}$$

5.2. Adverbs and Semantic Composition

5.2.1. Adverb Meaning

The semantic contribution of adverbs has long been a focus of generative linguistic research. Heny (1973) gives a cogent overview of the state of research on adverb meaning in the early 1970s, when much research on adverb meaning was done; though it was conducted on the basis of very different syntactic assumptions, this work nevertheless forms the foundation upon which much current work on the semantics of adverbs is based. We will examine two semantically different kinds of adverbs, illustrated in the previous section by the sentential adverb *obviously* and the manner adverb *skillfully*.

Within the LFG semantic tradition, Halvorsen (1983) discusses sentential adverbs like *obviously* and *necessarily* and proposes to treat them in the standard way, as proposition modifiers. The meaning of the sentence *Obviously David fell* is given in (47):

(47) *Obviously David fell.*

obviously(fall(David))

The predicate *obviously* takes as its argument the proposition *David fell*, and the meaning represented in (47) is roughly paraphrasable as *It is obvious that David fell*.

Heny (1973), writing at the time at which Nixon was the president of the United States, considers the following pair of sentences:

(48) a. *The U.S. president is necessarily a citizen of the United States.*

b. *Nixon is necessarily a citizen of the United States.*

As Heny notes, sentence (48a) is true under the rules of the constitution of the United States, while sentence (48b) is not necessarily true. In other words, though it turns out to be true that Nixon is a citizen of the United States, this is not necessarily the case, since Nixon could have decided to become a citizen of another country. On the other hand, it is necessarily the case that the U.S. president must be a U.S. citizen under the laws of the United States. The sentences in (49), containing the sentential adverb *obviously*, differ from one another in a similar way:

(49) a. *Obviously the running back fell.*

b. *Obviously David fell.*

Even in a situation where the running back fell and David is the running back, it may not be obvious that David fell, since the identity of the running back may not be clear. Adverbs like *obviously* and *necessarily* are *opaque* in their subject position, since different ways of referring to the same individual can affect the truth or falsity of the sentence (Quine 1953).

This aspect of the meaning of sentential adverbs is different from manner adverbs. Intuitively, a manner adverb like *skillfully* modifies the action that is performed, producing a new action that is performed skillfully:

(50) *David played skillfully.*

$\mathit{skillfully}(\mathit{David}, \lambda X.\mathit{play}(X))$

In (50), *skillfully* is a two-place predicate: its arguments are the person that performed the action (here, David) and the action that is performed skillfully (here, playing). In general, a manner adverb like *skillfully* takes two arguments, one corresponding to the subject of the sentence and the other roughly corresponding to the verb phrase — the action that is performed. For this reason, such adverbs are sometimes called *VP* or *verb phrase adverbs*. As we will see, however, meaning combination with adverbs like *skillfully* depends on f-structural relations like SUBJ, not c-structure constituency relations.

Unlike the situation with sentential adverbs, the following two sentences are both true if David is the running back and he played skillfully. Manner adverbs like *skillfully* are not opaque in their subject position, so that if David is the running back, the sentences in (51) are true in the same circumstances:

(51) a. *David played skillfully.*

b. *The running back played skillfully.*

5.2.2. Adverbs and Meaning Assembly

We assume the syntactic and semantic structures and meaning constructor in (52) for the sentence *Obviously David fell*. The f-structure for *obviously* is labeled

h, and its semantic structure h_σ contains the attribute VAR whose value we have labeled hv:

(52) *Obviously David fell.*

$$f\begin{bmatrix} \text{PRED} & \text{`FALL}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & g\begin{bmatrix}\text{PRED} & \text{`DAVID'}\end{bmatrix} \\ \text{ADJ} & \left\{ h\begin{bmatrix}\text{PRED} & \text{`OBVIOUSLY'}\end{bmatrix}\right\}\end{bmatrix} \qquad h_\sigma\begin{bmatrix}\text{VAR} & hv[\;]\end{bmatrix}$$

$\mathit{obviously}(\mathit{fall}(\mathit{David})) : f_\sigma$

From now on, we will simplify our representations by displaying only semantic structures whose internal structure is of interest in the constructions we are considering. Therefore, we do not display the semantic structures f_σ or g_σ corresponding to the sentence f-structure f and the subject f-structure g.

We propose the lexical entry in (53) for the sentential adverb *obviously*:

(53) *obviously* $(\uparrow \text{PRED}) = \text{`OBVIOUSLY'}$

$\lambda P.\mathit{obviously}(P) : (\uparrow_\sigma \text{VAR}) \multimap \uparrow_\sigma$

$\lambda P.\lambda Q.P(Q)$:

$[(\uparrow_\sigma \text{VAR}) \multimap \uparrow_\sigma] \multimap [(\text{ADJ} \in \uparrow)_\sigma \multimap (\text{ADJ} \in \uparrow)_\sigma]$

As in the previous sections, the lexical entry in (53) uses inside-out functional uncertainty to refer to the f-structure of the phrase it modifies. The expression $(\text{ADJ} \in \uparrow)$ refers to the f-structure modified by *obviously*.

The instantiated meaning constructors for the sentence *Obviously David fell* are given in (54): the meaning constructors contributed by *obviously* are labeled **[obviously1]** and **[obviously2]**, and the meaning constructors **[David]** and **[fall]** follow the proposals for proper names and intransitive verbs given in Chapter 9.

(54) Meaning constructor premises for *Obviously David fell*:

[David]	David	$: g_\sigma$
[fall]	$\lambda X.\mathit{fall}(X)$	$: g_\sigma \multimap f_\sigma$
[obviously1]	$\lambda P.\mathit{obviously}(P)$	$: hv \multimap h_\sigma$
[obviously2]	$\lambda P.\lambda Q.P(Q)$	$: [hv \multimap h_\sigma] \multimap [f_\sigma \multimap f_\sigma]$

Since the modifying adverb *obviously* is not itself modified, we first combine the two meaning constructor premises **[obviously1]** and **[obviously2]** to obtain the meaning constructor **[obviously]** given in (55):

(55) **[obviously]** $\lambda Q.\mathit{obviously}(Q) : [f_\sigma \multimap f_\sigma]$

As described in Chapter 9, Section 5.2.1, we can combine the premises labeled **[David]** and **[fall]** to obtain the meaning constructor labeled **[David-fall]** in (56):

(56) **[David-fall]** $\textit{fall}(\textit{David}) : f_\sigma$

Finally, we combine the meaning constructors **[David-fall]** and **[obviously]** to obtain the desired result, that the meaning of the sentence is $\textit{obviously}(\textit{fall}(\textit{David}))$:

(57) **[David-fall], [obviously]** $\vdash$ $\textit{obviously}(\textit{fall}(\textit{David})) : f_\sigma$

The derivation is semantically complete and coherent: we have obtained a wellformed, nonimplicational meaning constructor for the sentence, with no premises left unused.

The meaning deduction of a sentence with the manner adverb *skillfully* proceeds somewhat differently. The syntactic and semantic structures and meaning constructor for the sentence *David played skillfully* are given in (58), where the semantic structure h_σ corresponding to the adverb f-structure has the attribute VAR with value v and PROP with value p:

(58) *David played skillfully.*

$$f\left[\begin{array}{ll} \text{PRED} & \text{`PLAY}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & g\left[\text{PRED} \quad \text{`DAVID'}\right] \\ \text{ADJ} & \left\{ h\left[\text{PRED} \quad \text{`SKILLFULLY'}\right] \right\} \end{array}\right] \qquad h_\sigma\left[\begin{array}{ll} \text{VAR} & v[\ ] \\ \text{PROP} & p[\ ] \end{array}\right]$$

$\textit{skillfully}(\textit{David}, \lambda X.\textit{play}(X)) : f_\sigma$

Again, we assume a bipartite semantic contribution for the adverb *skillfully*. The lexical entry for *skillfully* is given in (59), and the instantiated meaning constructor premises for this sentence are given in (60).

(59) *skillfully* $(\uparrow \text{PRED}) = \text{`SKILLFULLY'}$

$$\lambda P.\lambda X.\textit{skillfully}(X, P) :$$
$$[(\uparrow_\sigma \text{VAR}) \multimap (\uparrow_\sigma \text{PROP})] \multimap [(\uparrow_\sigma \text{VAR}) \multimap \uparrow_\sigma]$$
$$\lambda P.\lambda Q.P(Q) :$$
$$[[(\uparrow_\sigma \text{VAR}) \multimap (\uparrow_\sigma \text{PROP})] \multimap [(\uparrow_\sigma \text{VAR}) \multimap \uparrow_\sigma]] \multimap$$
$$[((\text{ADJ} \in \uparrow)\ \text{SUBJ})_\sigma \multimap (\text{ADJ} \in \uparrow)_\sigma] \multimap$$
$$[((\text{ADJ} \in \uparrow)\ \text{SUBJ})_\sigma \multimap (\text{ADJ} \in \uparrow)_\sigma]$$

(60) Meaning constructor premises for *David played skillfully*:

[David]	$\textit{David}$	:	g_σ
[play]	$\lambda X.\textit{play}(X)$	:	$g_\sigma \multimap f_\sigma$
[skillfully1]	$\lambda P.\lambda Y.\textit{skillfully}(Y, P)$	:	$[v \multimap p] \multimap [v \multimap h_\sigma]$
[skillfully2]	$\lambda P.\lambda Q.\lambda Y.P(Y, Q)$	:	$[[v \multimap p] \multimap [v \multimap h_\sigma]] \multimap [[g_\sigma \multimap f_\sigma] \multimap [g_\sigma \multimap f_\sigma]]$

We begin the derivation by combining the premises **[skillfully1]** and **[skillfully2]** to obtain the meaning constructor labeled **[skillfully]** in (61):

(61) **[skillfully]** $\lambda Q.\lambda Y.\textit{skillfully}(Y, Q) : [[g_\sigma \multimap f_\sigma] \multimap [g_\sigma \multimap f_\sigma]]$

The right-hand side of the meaning contribution of the intransitive verb *play*, $g_\sigma \multimap f_\sigma$ exactly matches the requirements of **[skillfully]**. We combine **[skillfully]** and **[play]**, obtaining the meaning constructor labeled **[skillfully-play]** in (62):

(62) **[skillfully-play]** $\lambda Y.\textit{skillfully}(Y, \lambda X.\textit{play}(X)) : g_\sigma \multimap f_\sigma$

Finally, we combine **[skillfully-play]** and **[David]** to obtain a wellformed, semantically complete and coherent meaning constructor for the sentence:

(63) **[skillfully-play], [David]** $\vdash$ $\textit{skillfully}(\textit{David}, \lambda X.\textit{play}(X)) : f_\sigma$

6. FURTHER READING AND RELATED ISSUES

There has been much work on modification within LFG, particularly on the syntax of modifiers and adjunction, that has not been discussed in this chapter. In particular, Butt et al. (1999) discuss the syntax of adjectives and adverbs in English, French, and German, and Colban (1987) provides a syntactic and semantic analysis of prepositional phrases as verbal arguments and modifiers.

We have also omitted definition and discussion of scoping relations between modifiers. As noted by Andrews (1983b), Pollard and Sag (1994), and many others, the contribution of modifiers to the meaning of an utterance can depend on the order in which they appear:

(64) a. *Kim jogged <u>for twenty minutes</u> <u>twice a day</u>.*

b. *Kim jogged <u>twice a day</u> <u>for twenty years</u>.*

Syntactically, modifier scope is defined in terms of *f-precedence* (Chapter 6, Section 4.4), and semantic scope relations are in turn constrained by the syntactic scope relations defined by f-precedence. Crouch and van Genabith (1999) provide a theory of scoping relations and how they can be imposed within the glue approach.

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